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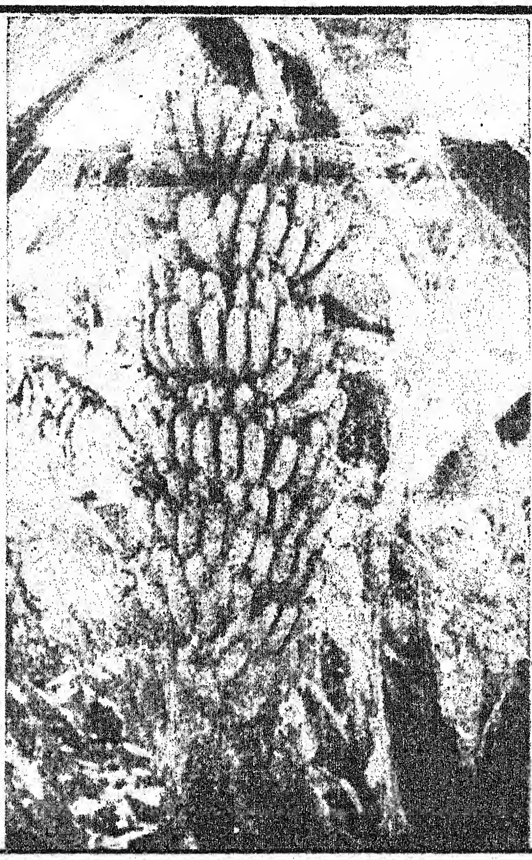
BANANA  NUMBER

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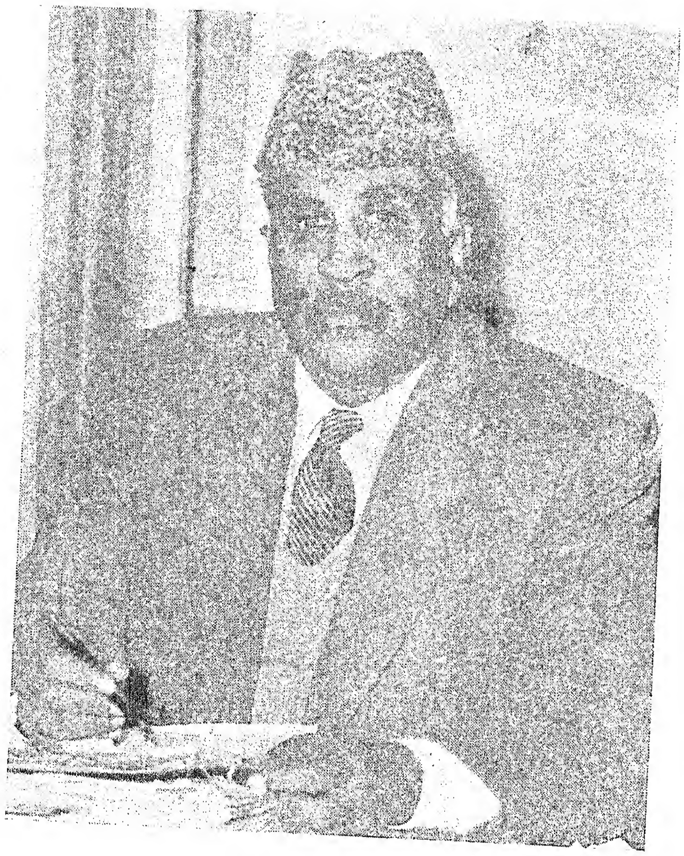

MALIK KHUDA BAKHSH, S.K.
Secretary, Government of West Pakistan, Agriculture Department

Message from MALIK KHUDA BAKHSH, S.K.

Secretary to Government of West Pakistan Agriculture Department

¶ Although Pakistan is renowned for best varieties of Banana yet West Pakistan had little or no banana production at the time of Independence. The need was not felt to promote banana cultivation in this part of the country since it was imported in abundance from Bombay and was available in our markets at very cheap rates. With the partition of the country it became necessary to produce this important article of diet in the area which now constitute W. Pak.

¶ It is gratifying to note that due to constant endeavour of the Agriculture Department the cultivation of superior banana varieties has been established on commercial scale in Hyderabad Division and it is only a matter of a few more years that this fruit will become available in sufficient quantities in our markets and would help in saving foreign exchange now being spent on its import. Work is in progress to acclimatise some superior banana varieties in other parts of West Pakistan or to find out the protected pockets where the promising varieties can be grown. As a result of these efforts, cultivation of Basrai variety at Kalabagh and Sialkot has become successful. It shows that given the will, skill and resources, we cannot only achieve difficult tasks but can in fact make the impossible possible. I congratulate all officials of the Agriculture Department and the banana growers on this notable achievement.

¶ West Pakistan Co-operative Fruit Development Board has done well to bring out a special issue of the "Punjab Fruit Journal" on this important fruit. This would help the growers understand the important problems in its cultivation, and thus a sound foundation of this new enterprise in the Province would be laid. I congratulate the management of the Board on their this effort. —KHUDA BAKHSH

Commander ABDUL LATIF
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FOREWORD

BANANA cultivation in West Pakistan is a very recent enterprise. Very little research work can be traced to this part of the country in the era before the creation of Pakistan. Banana lovers can well imagine the difficulties encountered by them in procuring this fruit after the partition of India when the trade embargoes were placed on the import of Indian fruits. This unprecedented paucity of banana fruit led to the stimulation of thought and action of those who were at the helm of affairs of the Department of Agriculture. The Annual Programme of Research of the Agricultural College and Research Institute was accordingly remodelled and pursued with vengeance with the result that banana cultivation has become a reality and the area under this fruit is now on the increase. The enterprisers of banana cultivation have found ready market for their produce which is now easily available for the children and the patients alike. To achieve this tangible result notable efforts have been made, among others, by the Fruit Section of this College and Research Institute during the last one decade. Besides guiding and initiating work on the selection of banana varieties suited to the conditions prevalent in this area, research on methods of cultivation and curing have also been carried out. This Banana Number of the *Punjab Fruit Journal* seeks to present at one place all the latest information available on the cultivation of this fruit and it is hoped that the existing and the intending banana growers as well as consumers will be benefited greatly by the information contained in this volume. The information packed in this brochure will re-assure the consumers of this fruit the nutritive basis of their sound selection in favour of banana and for developing bias for this inimitable fruit. I am confident that the day is not far off when, with the concerted efforts now being made by our Fruit Specialists, we will not only be self-sufficient in the supply of this fruit but will also start its export to our less fortunate neighbours.

I wish the organizers best success in their endeavour to compile this volume.

ABDUL LATIF

Principal, Punjab Agricultural College and Research Institute, Lyallpur.

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BANANA CULTURE

By

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Fruit Specialist, Agricultural College, Lyallpur

ORIGIN

It is believed by most of the authorities that Banana originated in hot tropical regions of South Asia and probably in Indo-Malayan regions. Jessen[3] stated that Alexander the Great found bananas growing in the valley of the Indus river as early as 327 B.C. It has been reported that Banana was carried from its original home into Pacific by the first migration of POLYNESIANS about the time of Christ. Man in his wanderings, probably also carried it Eastward to India, the Mediterranean region and finally to tropical American countries.

BOTANY

Banana belongs to Genus *Musa*, family *Musaceae* and natural order *Scitamineae*. The banana varieties important in world trade belong to *M. sapientum* and *M. cavendishii*. Gross Michel, a variety which has monopoly over world trade belongs to *M. sapientum*. The fruits are rather large and very well flavoured.

Short-stemmed bananas include most of the edible varieties of Indo-Pak Subcontinent. Basrai and Champa varieties are 2 important examples and these belong to *Musa cavendishii*. Tall growing varieties are not regarded as suitable in this locality, because they cannot withstand the strong winds and protecting them from frost is nearly impossible. In this region tall growing varieties also do not produce good-quality fruit. The plantain, with large fruits and tall growing habit, in which good percentage of starch does not convert into sugars is used for cooking purposes, and belongs to *M. paradisica*.

Cultivated banana varieties are numerous and their classification is very confusing. It is due to this, that the same variety has different names in various banana producing countries.

IMPORTANCE AS DIET

There is little doubt that Banana was the first food of man and one of the first plants cultivated. It was known throughout the warm, moist region of South-East Asia in prehistoric times.

Among fruits it has the same position as potatoes and sweet patatoes in vegetables. It can yield 1000 mds. of fruit per acre under ideal conditions of its growth and development, thus has great potentialities in solving the world Food problem. The banana is considered the most important energy-producing food and leads all other fruits in food value. In fact, in many Pacific and Atlantic tropical islands, this fruit is the only staple food of the natives. It is liked by all classes of people due to its delicious taste and flavour.

Banana is very rich in minerals and vitamins and is the cheapest source of most healthful diet. It contains as much as 20% sugars and more than 1% starch and other carbohydrates, when ripe. It is a fair source of calcium and iron and is quite rich in Potassium, Phosphorus, Magnesium and Sodium. Both Iron and Phosphorus in this fruit are 100% available. Though protein percentage is very low in the fruit yet it can be directly assimilated in the body. It also contains vitamine A, B and C in reasonable amounts, higher than many of fruits and vegetables. Comparison can easily be made from the table given here.

Table I—Vitamin Contents of Banana as compared with other fruits

(Vitamin content in 100 gms fresh edible portion)

Commodity		Vitamin A (carotene) I.U.	Thiamine μg	Riboflavin μg	Ascorbic Acid μg
1. Bananas	...	50-332	42-62	87-88	3-11
2. Apples	...	75	25	73	5-8
3. Oranges	...	62-286	78	32-45	52-72.5
4. Grape-Fruit	...	0	...	37-45	27-45
5. Pears	...	10	25	76	3-5
6. Tomatoes	...	1000	78	52	21-24
7. Cabbage	...	0-100	81	44	50-90
8. Carrots	...	2100	72	66	3-5

The palatability, food value and the easiness with which banana can be assimilated in the body, makes this fruit as one of the choicest fruits.

PRODUCING COUNTRIES

The important countries in the field of producing Banana are:—

1. **Brazil.**—It is the largest producer of Bananas, producing 39% of the total world's production. Larger quantity of its production is used for meeting the domestic demand. Not much, therefore, is exported from this country.

This fruit is produced in all Brazilian states, but 60% of commercial production is in Sao-Paulo, Rio de Janeiro and *Minas-Geraes*. The *Sao-Paulo* produces about 25% of all Bananas produced in this country.

2. **India.**—Second, in this field, is India with 21% total world production. The important localities producing banana are the states of Madras, Andhra, Bengal, Bihar, Assam, Kerala, Basseine, Jalgaoun Mysore and Bombay.

Basrai is the best among all cultivated varieties and is liked throughout the country. In 1952, out of 42,300 acres of Banana in Bombay, 70% of the area was under Basrai. Variety withstands hot and dry weather better than other varieties and has become most popular in many tropical countries.

3. **Pakistan.**—Pakistan is the third largest banana producing country of the world. Pakistan produces 3,79,63,596 mds. of bananas in 92,854 acres annually, which is about 15% of the world production. Most of the area is situated in East Pakistan. West Pakistan is deficient in this fruit. 95.7% of total area under this fruit lies in East Pakistan.

	Area Acres	*Production* Maunds
East Pakistan	88,800	3.79,36,112
West Pakistan	4,054	27,484

The most important varieties grown in East Pakistan are Amrit Sagar, Dud Sagar and Cheena Champa. Local (desi) variety is prominent in West Pakistan though Basrai variety is also successful in many localities. So far Pakistan has not entered in Banana world trade.

Honduras, Guatemala, Costa Rica, Mexico, Nicaragua and Cuba are the biggest banana exporting countries in the world, though not the largest producers.

Other banana producing countries are Panama, Dominican Republic, Haiti, Jamaica, Columbia, Ecuador and Canary Islands. Bananas are cultivated throughout Equatorial Africa, the largest areas being in British Cameroons and French West Africa. Other important areas are ivory, Mozambique and Eritrea in Africa. In Asia, Formosa had been a leading Banana exporter. Bananas are also extensively grown in Queensland in Australia.

DISTRIBUTION IN PAKISTAN

Large-scale production of Bananas is confined to East Pakistan. It is the only fruit available throughout the year in plenty. Whereas its production in West Pakistan is limited. If shipped as an ordinary cargo, it does not last the journey, and due to lack of refrigeration facilities in our cargo vessels, fruit from East Pakistan to West Pakistan is not being shipped in any appreciable quantity. Due to this in spite of the fact that Pakistan is 3rd largest banana producing country, banana is a rare commodity in W. Wing.

1. **East Pakistan.**—Although banana is cultivated all over the province, yet largest plantations are found in Dacca district. Total banana production of the province is 3,79,36,612 maunds from 88,800 acres 16-17% of this is being produced in Dacca. Rajshahi, Rangpur, and Mymensingh are other producing areas in East Pakistan.

The best quality bananas of East Pakistan are Amrit Sagar and Dud Sagar. Cheena Champa has also fair demand.

2. **West Pakistan.**—Former province of Sind is second in producing banana in Pakistan, although, by this time, production is very meagre. It produces 15,409 maunds annually from 3,845 acres. The major producing district in this region is Larkana which produces 14,960 maunds from 3,740 acres. Tharparker, Hyderabad and Nawab Shah districts are also producing banana to some extent.

Local varieties which are cultivated in this area have soapy consistency, hard core and skin adhering to the flesh, edible portion, even when the fruit is fully ripened. Quality therefore is very poor. Basrai variety has recently shown very promising results. Large areas are now being put under this variety throughout lower Sind areas.

3. **Divisions of Peshawar and Dera Ismail Khan :** also producing some quality of bananas, 7,800 maunds in 78 acres. The larger production is in Bannu *i.e.*, 7,300 in 73 acres and 500 maunds in 5 acres in Hazara district. Only inferior varieties of banana are grown in this region.

The work for the improvement of bananas has, however, been started. Following 6 varieties from East Pakistan were introduced in March 1951 to study their performance in this region.

1. Amritsagar. 2. Singapur.
3. Cheena Champa. 4. Agniswar.
5. Dud Sagar. 6. Safri.

Out of these varieties only Cheena Champa and Safri varieties are recommended in this area.

In fact, Haripur, Charsadda, Bannu district and Dargai area (Malakand Agency) have got large scope for crop, especially with the construction of irrigation projects.

In the former province of West Punjab, the area under this crop is negligible. In Bahawalpur division 31 acres are under bananas, producing 3,875 maunds. Average yield in Bahawalpur division is 125 maunds per acre. Local (desi) varieties are extensively cultivated, which are not up to the standard for table purposes.

Acclimatization and selection of varieties of different fruits have been a regular feature of Fruit Section at the Punjab Agricultural College, Lyallpur. Some trials on bananas have also been conducted from 1935—40, wherein 80 varieties of Banana collected from Bombay, Madras, Calcutta and Malaya states and many other parts of United India were included. These trials were confined to Lyallpur conditions only and no serious attention was paid to extend its cultivation throughout the province. When the efforts to find out a suitable variety for this tract, ended in failure due to severe climatic conditions, the further research work was abandoned altogether as the fruit which used to come from Bombay side was available in our markets in abundance and used to sell at a very cheap rate.

The plantation at Lyallpur suffered severe damage from frost in winters and from hot dry winds in summers. Consequently a large number of varieties died away and those which survived gave very little fruit of inferior quality.

The following varieties were included in these trials :—

1. Peyan 2. Rastali
3. Konda Monthon 4. M. Monthon
5. Vellular No. 2 6. M. Dacca Maralabum

7. M. Cavendish	8. M. Kantali
9. Vellular No. 1	10. M. Murtabum
11. M. Kunchkale	12. Paicha Nadan
13. Monthon	14. Pachbala
15. Naindia Bala	16. Kandali Bala
17. Ras Bala	18. White Chekra Kale
19. Kilandi	20. Imrati
21. China Balai	22. Karpura
23. Bontha	24. Sagunda Bhalai
25. Bothisa	26. Halili
27. Yalakhi Balai	28. Gaju Balai
29. Raja Balai	30. Puttu Balai
31. Devi Gosha	32. Ave Balai
33. M. Champanar	34. Kela Bansi
35. Parachenar	36. Safed Valechi
37. Basrai	38. Valah
39. Lal Valechi	40. Kabuli
41. Rajoli	42. Paichailandan
43. Separi	44. Hazara
45. Rawalpindi	46. Dora Balai
47. Mauritius	48. Maul Wain
49. Red	50. No. 84
51. Pind Dadan Khan	52. No. 80
53. No. 81	54. No. 79
55. Elachi	56. Elsi
57. Ram Kela	58. Kanai Bansi
59. Chatin	60. Rajpuri Puna
61. Badd Balai	62. Agll Sebook Always
63. Gruthelahim	64. Rai Kela
65. Kalibo	66. China Champa
67. Lonkel Chanda	68. Lalon
69. Awak Legor	70. Raja Udang
71. Rajah	72. Hijan
73. Rastali	74. Ps. Vine No. 1
75. Grewal Nursery	76. Desi
77. Hazara Farm, Harapa	78. Amartaman
79. Amritsari	80. Dindigul

After the partition great scarcity of the fruit is being experienced. In 1953-54, fresh approach to the problem was made when a survey of whole the area was made to find out suitable localities with suitable climatic conditions for different promising varieties of good quality fruit.

Twenty promising varieties were selected from different imported varieties. Cultivation trials had been started in Lyallpur, Gujranwala, Sialkot, Kalabagh, Choa Saidan Shah and many other places somewhat better suited for its cultivation.

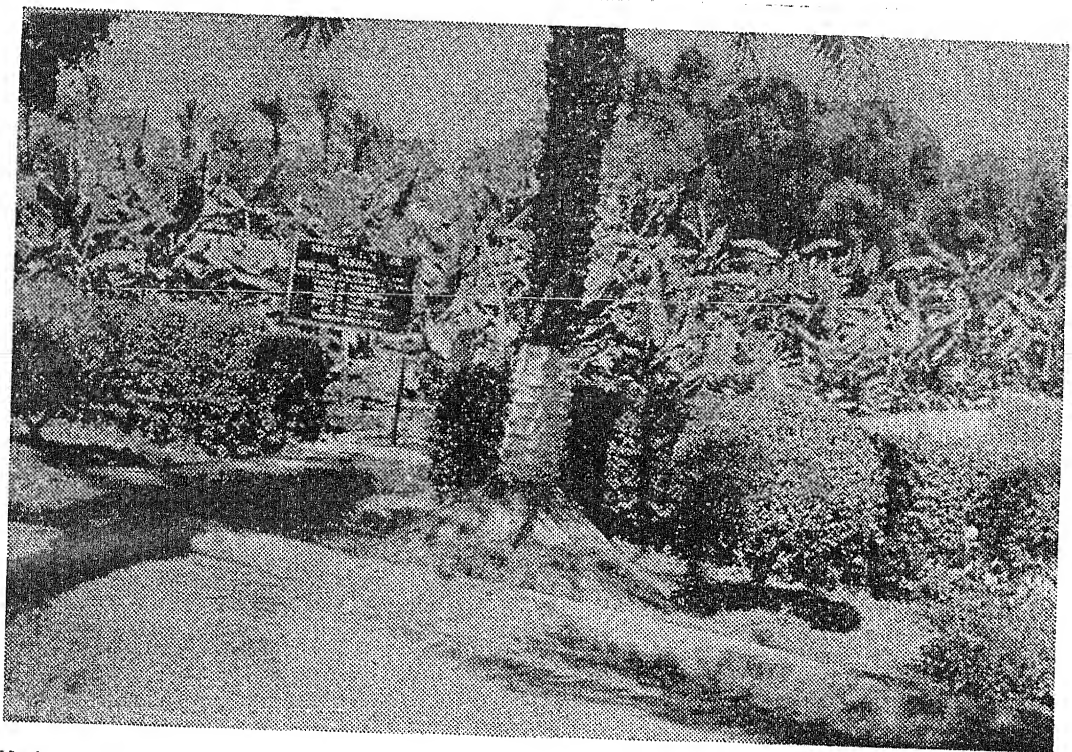
At Lyallpur and Gujranwala the success has been poor, but at Sialkot, Kalabagh and Choa Saidan Shah, many varieties have given good quantity of better quality fruits. At Sialkot varieties S_7, S_8, S_9 and Philippine variety were most successful. The imported variety Amrit Sagar from East Pakistan, Soneri, Soni, S_1, S_2, S_6, and M.B. gave poor results, so these were discarded. So far results obtained at Kalabagh are very encouraging. Basrai and Cheena Champa varieties have shown great promise at this place. This is attributed to the fact that Kalabagh due to proximity of river Indus is comparatively more humid during summer and has mild winter.

In spite of many disheartening results at various places there is still hope, because the failure is due to severity of our climate and that can be modified to some extent artificially. Watering regularly after third fourth day during summer; planting banana plants in between the rows of tall fruit trees, provision of strong wind-breaks and overhead spray irrigation would minimise the damaging effects of scorching summers. The same steps would also prove helpful in the prevention of frost injury. Heating of banana plantations by burning crude oil burners, fuel wood, trash etc. on frosty nights would further be needed to make banana culture possibe in this tract. New trials at the Experimental Garden, Lyallpur are being laid out keeping in view the above mentioned observations. The following varieties and selections have been included in these trials :—

1. Basrai 2. Philippine 3. Soni 4. Selection 1 5. S_2 6. S_6 7. S_7 8. S_8 9. S_9 10. S_{10} 11. S_{14} 12. S_{17} 13. S_{18} 14. S_{22} 15. Soneri 16. A.H. 17. Begowal 12. Ceylon No. 1 19. S_{21} 20. Ceylon No. 3.

CULTIVATION OF BANANA

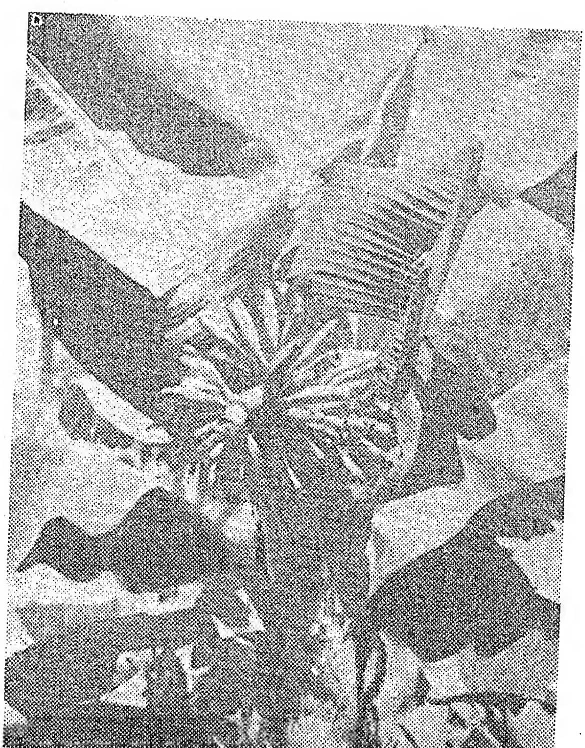
Climate : Banana is strictly a tropical fruit. It requires plenty of warmth and humidity throughout the year. It cannot withstand higher temperatures more than 105°F (40.5°C) accompanied with strong and hot dry winds during summer and low temperature below 50°F (10°C) in winter. It requires frequent and well distributed rainfall throughout the year and absolutely no frost in winters. This crop grows and yields abundantly in the warm, humid and rainy climate of the tropical regions on both sides of the equator. Such ideal conditions for this fruit are not found in the canal colonies of Lahore, Multan



Varietal Trials on Banana in the Experimental Garden, Lyallpur ↑

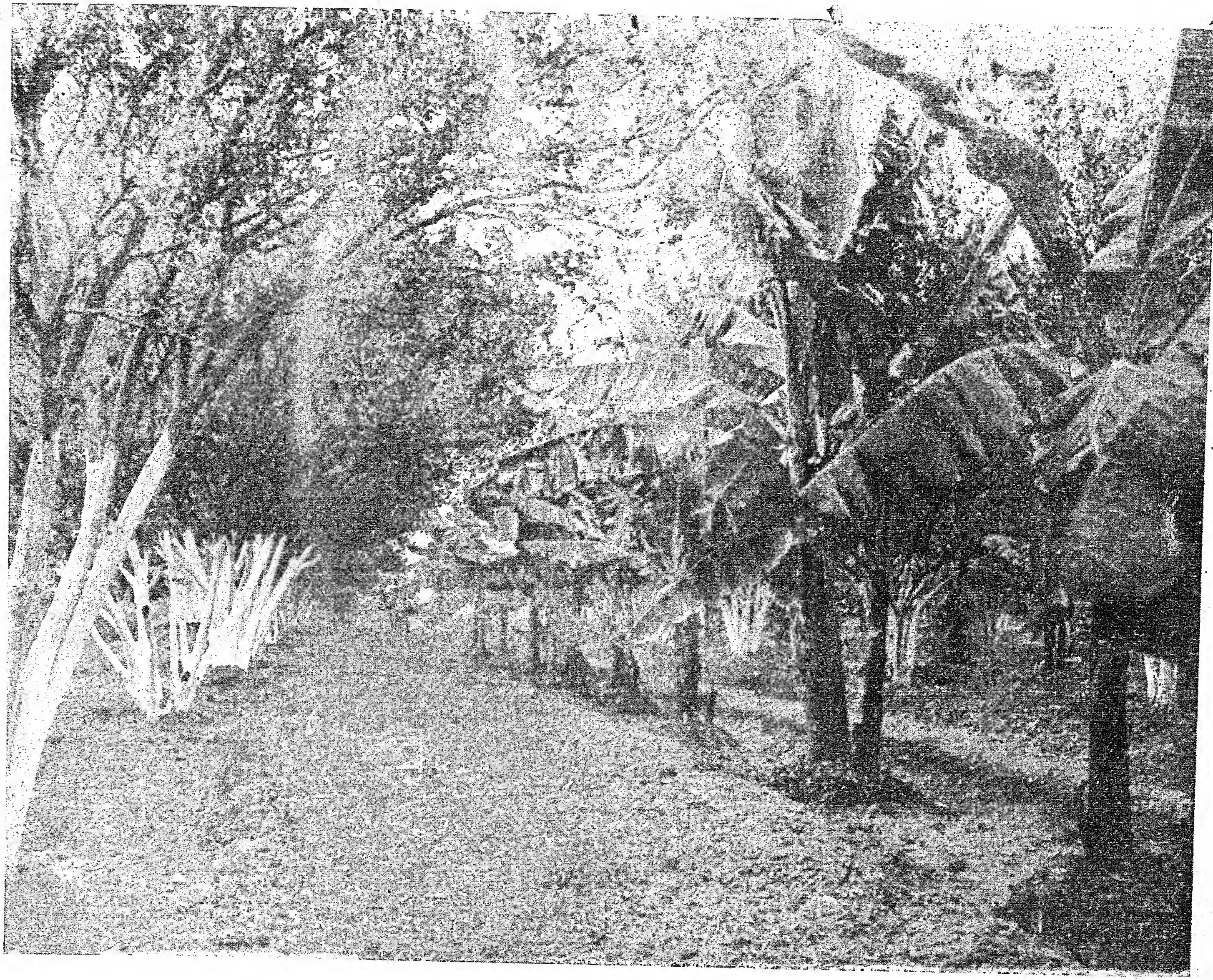
Manurial Trials on Banana at Government Nursery, Lyallpur →

Newly Emerged Floret

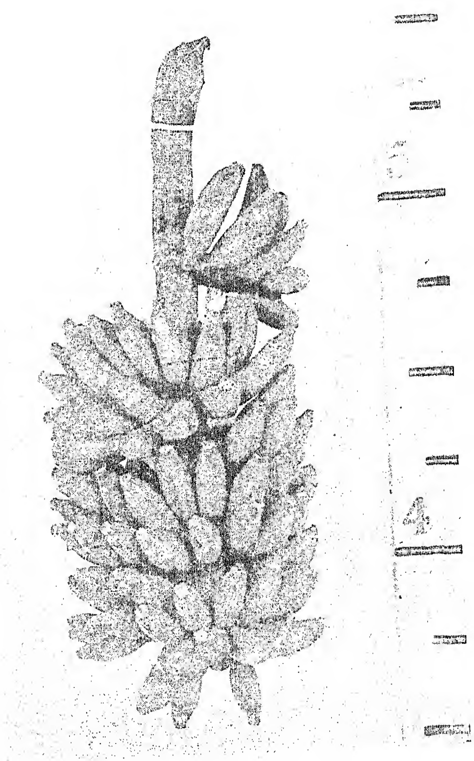


Bunch of Banana Fruit after the Male Flowers have been removed

Cultivation of Basrai Variety has Proved a Success at Kalabagh Estate



Banana Being Grown in Between the Rows of Malta Plants at Kalabagh Estate



CHAMPA

Rawalpindi and Sargodha Divisions.

If copiously irrigated during summers and artificially protected from frost in winters, there is possibility of growing banana in protected places in this region. Many trials of this nature are being conducted. Windbreaks of deep-rooted plants or thick hedge of local kela (plantains) have proved better for protecting the crop from high winds and frost. These windbreaks are beneficial when planted on western and south-western sides of plantations.

Transpiration in this case is maximum due to having a large leaf and body surface. In order to make good this rapid loss of water frequent irrigations are very essential during summers. The rows of bananas planted in between lines of citrus, Mango or guava plants are less exposed to deterrent effects of desiccating winds during summer. Growing of 'Janter', in between lines of banana plantation during early season, is also proving beneficial at many centres. Bananas planted along river banks are flourishing well.

For protecting bananas from frost an additional precaution has also been practised in Madras and certain other parts of India. They produce smoke of dried grass and other useless materials whenever there is any danger of frost. For this purpose special kinds of smokers and burners devised in other countries can be used with advantage. However, even this device cannot be taken as hundred per cent answer to the problem since any negligence even for one frosty night wipes out the crop.

Soils : Banana grows well in fertile, medium loam and well drained soils. Depth, water-holding capacity and good drainage of the soil are among the essential requirements for banana growing. Banana roots penetrate through first one and a half feet but sometimes these go as deep as 3 feet.

Banana is not susceptible to minute chemical changes in the soil. It can be cultivated in varied types of well-drained open soils providing abundance of nitrates, potash, phosphorus and lime. It does not flourish well in dense clayey soils and heavily alkaline soils. The soils of former province of West Punjab are very suitable for banana cultivation, provided all other ideal conditions which are necessary for its development are also available. River banks are most suitable, having a fresh dressing of silt every year.

Planting season : There are two planting seasons of banana in this tract *i.e.* spring season in February, March and Monsoon in August-September. The banana plants under favourable conditions starta flowering normally after 9—12 months of their actual planting. Therefore plantations which are established in February-March, flower in next January-February, and get a good developing season in coming warm months crop nourishes well and produce a good quality fruit in large quantity. On the other hand plants, planted in August, September, get an untimely check by coming winters. These plants start flowering in the next July-August and these flowers have to nourish in winter and are mostly damaged by frost in this region. Winter season is a serious drawback in this province. Therefore the best season for planting banana in this part of the province is spring.

Maximum supply of this fruit is during September-October. These plants bear fruits almost throughout the year, but the production goes down in winter *i.e.* November to February ; only 15—20% supply is seen in these days.

Planting : As explained above planting season varies in different parts, but the best time for planting in this region is February-March.

Planting distance is different in different places, depending upon the variety, climate, soil and other conditions. Basrai variety requires somewhat liberal spacings. The usual spacing varies from 8—10 in East-Pakistan and in this way 400 plants can be established in an acre on an average. In the former Sind areas (6′) 400—500 plants per acre and former N.W.F.P. 400—600 plants are generally grown in one acre. But in former province of West Punjab due to severe climatic conditions close planting 5′ to 7′ is recommended, and this helps in conserving humidity to some extent. Planting at 10′—15′ apart has no definite advantage in this locality. In fact in many observations greater yield per acre has been secured with plants 6 feet apart than 9 feet.

Trenches 2′ wide and 2′ deep at prescribed distance, are dug in well prepared soil. Trench planting is an easy method. After planting the suckers at recommended distance, all the trenches are filled with mixture of F.Y.M. and surface soil up to 6″ above the level of the soil. Suckers may also be planted in 2′×2′ pits.

The suitable young suckers are separated by a side stroke from the mother plants and used for further propagation. Small pieces of rhizome can also be used in banana propagation. There are two types of banana suckers usually found :

1. Sword Suckers : Having long leaves or narrower and longer leaves.
2. Water Suckers : Having broader leaves. Sword suckers are preferred every where.

At the time of planting all the leaves of suckers except sword leaves are pruned away, cutting of whole the top is dangerous for plant life when suckers are of very young age.

Manuring : Manuring is a problem of extreme complexity. Practices in world range very widely. It requires a good amount of nutrients throughout its life due to its short life and heavy vegetative growth.

In Mirpur Khas, application of 50 cart-loads of F.Y.M. per acre at the time of planting and 100 lbs. of Nitrogen derived from ammonium sulphate in 2 equal doses as top dressing, 3 months and 7 months after planting is advocated.

In Bannu district, 50 cart-loads of F.Y.M. is added before planting and 4 lbs. of ammonium sulphate per group of 8—10 plants in 2 applications in the months of February and September are recommended.

In former province of West Punjab adding of 50 tons of F.Y.M. per acre at the time of planting and a maximum of 5 seers of cotton seed cake with ½ seer of ammonium sulphate to each and every stool in April and same dose in September, is a usual practice, and has given good results.

According to Nayyar and Bakthavathsabe (1955) in India, bananas are grown on black cotton soils and before planting about 50 tons of manure/acre is incorporated in the soil. In addition to the first dose of the manure 0.4 lbs. of nitrogen per plant is also recommended and this is frequently given in 2 applications of groundnut cake at the rate of two tons/acre, but some growers replace it with ammonium sulphate.

Decayed leaves and stalk once fruited are also a good source of natural manure.

Irrigation : Weekly irrigation is recommended during summers and fortnightly during winter. Soil should not be allowed to dry up in summers, yet standing water is harmful. This would mean even more frequent irrigations during summer months. The amount of water is also affected by the nature of the soil and the weather of the locality. Therefore, the canal water supplies should also be supplemented with tube wells, because canal closures endanger the plant life.

In canal colonies, bananas are generally planted on the "bunds" of 'Khals' and this ensures better moisture supply.

Pruning : On suitable soil and under favourable climatic conditions banana plant produces many shoots from its underground stem. These shoots are called suckers. Over-growth of suckers adversely affect the cropping potentialities and the crop borne remains of smaller size and of inferior quality. In order to harvest good sized fruit of superior quality, mother banana plant should be allowed to grow singly and the suckers should be constantly chopped down to ground level without giving any shock to the mains talk. In this way only one crop during a year would be harvested. However if it is intended to spread the availability of the fruit, three suckers in different stages of growth may be allowed to grow. The main stalk after the harvest of the crop should be cut down and chopped and incorporated in the soil. From the remaining suckers, the tallest one would assume the position of the main stalk and fruit in due course of time. In Bombay Presidency, generally such ratooned crops are not taken and more often bananas are planted as annuals.

Bearing habit : The banana plants flower in 7—10 months under favourable conditions. The colour of the inflorescence varies somewhat in various varieties of banana.

On the inflorescence stalk first to appear are the female flowers, these are followed by neuter flowers, on the tip enclosed in maroon coloured bracts are staminates.

Banana inflorescence appear in spirals around the flower stalk. The pendulous ball of perianth leaves on the tip of the inflorescence, known as heart, should be removed as soon as the pistillate flowers have set fruits. Bleeding should not be allowed from cut portion. Melted wax should be applied to this cut portion to stop bleeding or it should be burnt dried with a red-hot iron.

Each spiral of flowers forms a hand of bananas. Each hand is composed of 10—12 fingers. Bananas of commercial grade have 7 or more hands on one stem but on an average the number of hands on one stem is between 9—11.

In the beginning small bananas are pointing downward, but as the fruit grows, they turn outward and by the time they are ready for harvesting, they are pointed upward. The seedlessness in bananas is due ot the fact that all the commercial varieties produce fruits without fertilization.

Harvesting : The banana fruit is seldom allowed to ripen completely on the tree. It ripens best when it is picked green at its full maturity. Banana bunch should be cut down when fruit has attained full size, indicating the grade and maturity. Some indications of maturity are that when fruit changes its colour from deep green to light green and floral ends of the fruit are shed down with the slightest touch of the hand. Another indication is that upper portion of top fingers turns somewhat yellowish. Bananas are picked green and hard when to be transported over a long distance.

The bunch is cut at least ten inches above the first hand of the fingers. Care should be taken to avoid staining by the sap from the cut and the fruits should not be bruised by careless and rough handling, as the injuries would cause blackening of the skin in ripening. Bunches should be cut just before they are to be transported.

In some countries bananas are graded according to their size, but in some localities of India, the fruit is sorted according to the number of fingers in each bunch of the fruit.

The system of transport must be such that fruit should reach even distant markets in the same fresh and green conditions in which it is picked and loaded. Curing is done usually in the markets where it is sold to retail dealers.

Curing : After harvesting, the main thing in Banana Industry is its curing. It is a general view of many workers of this subcontinent that we produce good quality bananas but cannot cure it properly, so we deteriorate its quality by our inferior methods of curing.

The banana seldom ripens on the tree and the ripening has therefore, to be carried out after harvesting, the fully developed fruit at the green stage. This is done in what may be termed 'curing chambers' which can be pits dug in the ground or rooms which are capable of being closed air-tight.

The following curing method is recommended :—

Smoke Curing : The whole bunches or 'hands' removed from the bunches are closely packed in between banana leaves in the curing room or pit. If a curing room is used, ordinary charcoal or dung cakes are burnt inside the room and sufficient smoke created to permeate the packed fruit. In case of a pit, the smoke is created in an inverted flower pot by burning dried leaves or dung cakes in it. The inverted flower pot is placed over the small opening in the pit, the rest of the pit mouth having been covered ever. The smoke is then blown into the pit through the drainage hole in the bottom of the flower pot until sufficient smoke has entered the pit. The door of the curing room or opening of the curing pit is then closed air-tight and left for 12 hours. The smoke treatment is repeated morning and evening for 3 days after which the fruit is removed and left in a cool airy room for ripening or sent to the market where it ripens while waiting for retail sale. During curing the fruit should not be allowed to dry and temperature should be from 68 to 70°F.

PESTS AND DISEASES

Since banana had not been an important crop of the region, no serious attempts in the past had been made to know its various dieases and pests to devise control measures. Stem rot and blackening of fruit are common fungal diseases of this fruit in this region which deteriorate the banana fruit quality and lessen its production. Much work on these maladies had been done in other banana producing countries in the world.

Rust, thrips, banana borer, banana-stem weevil, root stock borer, fruit beetle and other minor pests like bagworm and scale insects etc. are main insect pests of the sub-continent, which cause some loss in production and deteriorate the quality of the fruit. Spraying with DDT and BHC is very effective, in the control of many of these pests. The infested plants and suckers should be burnt down soon after removing. The most important insect pests of this crop are as follows:

1. BANANA WEEVIL BORER

(*Cosmopolites sordidus* germ)

It is also called Root-stock Borer or Banana stem borer.

It attacks generally Banana suckers, its grubs bore in the rhizome and weaken the plant, which ultimately dies. The adult insects are found in the soil under dried banana leaves at the base of the stem. Its greatest attack is from April to October.

The insect multiplies in great number in infested plant especially under waterlogged conditions. The best method for its control is to destroy and burn the infested plants. Care should be taken at the time of Banana plantation, that perfectly healthy suckers are planted in well-drained soils.

Spraying with DDT three times with fortnight intervals reduced the infection. A ring of 50 gms of 25% BHC around the plant stem is also recommended[2].

2. LEAF AND FRUIT BEETLE

(*Nodostomo subcostatum*)

Attack of this beetle spoils fruit and impairs the flavour. It is more destructive in August and September. It prefers feeding on leaves about to emerge. Its grubs are found near the roots of suckers. To avoid this disease clean cultivation is required. Malbhog and Champa banana varieties are most susceptible DDT or BHC spray is effective.

3. FRUIT-FLY

(*Dacus tryoni* Frogg)

It is one of the very important pests. According to Tryon[4] this fly punctures the peel and lays eggs underneath. It attacks when this fruit has not yet attained full size. The puncture is noticeable by a little black spot which later widens, forming a blotch of discoloration. Finally the maggots of this insect enter into the pulp which decays soon afterward.

The banana is susceptible to a number of diseases but fortunately in Indo-Pak sub-continent, the loss is not as serious as in other countries.

The most destructive diseases, to which Bananas fall a prey, are very briefly given here.

(1) **Panama Disease.**—It is one of the most important diseases of Banana plant. It is not much serious in Indo-Pak sub-continent. It widely occurs in Central America and West Indies. Rasthali and Sonkel varieties are very susceptible to this. Some 25 years ago, near Poona whole Banana plantations of these varieties had been completely devastated due to this and were replaced by Basrai variety which is fairly resistant to this. It has been reported that one variety which is susceptible in one country be resistant to this disease in the other.

The disease is caused by a soil borne fungus called Fusarium oxysporum cubense. Loesecke[5] described the symptoms of the disease in the following words.

A typical diseased plant first shows a yellowing of the lower outer leaf blades and peticles. The change from green to yellow is usually sudden and startling. The leaves begin to wilt and within a day or two the fleshy leaf buckles at a point 3 or 4 inches from the pseudostem. The

withered leaves brown, and finally the plant, weakened by disease, falls to the ground. The symptoms described may vary in different plantings. In some instances there is a dwarfing or stunting of the entire plant, and the leaves on such plants do not wilt as rapidly as on larger plants.

If a bunch of fruit has formed on the attacked plant, the bunch will generally be found to be small, and development may be completely arrested after a few hands have formed. If the normal number of hands have already been formed, the individual fingers are small. The ovary is constricted at the calyx end giving the fruit the appearance of a "bottle neck". The fingers will not ripen uniformly, and occasional fingers may become rapidly yellow with a pithy flesh and a "starchy" taste. There are also well-marked changes in the internal tissues of the banana plant itself.

As a control measure, the whole infested plant must be dug out along—with underground stem and roots, and burnt down immediately. The soil from where infested plants have been removed should be sterilized or mixed with quicklime at the ratio of 1 : 3 and soaked well. The replanting of Banana should not be carried out in any case on highly infested soils.

Meredith[2] has shown that mercury compounds will kill fusarium oxysporum C and prevent its spread.

(2) **Bunchy Top.**—It is one of the destructive diseases of Banana in all tropical countries including Indo-Pak sub-continent. No satisfactory measure has yet been known to keep the plants free from this virus diseases, as the plant louse Pentalenia nigronervosa, the carrier of the viruses, cannot be killed by spraying poisons, as they live on underground parts of the plant.

The variety of Bananas most affected is Basrai varierty in all tropical countries.

The infected plants remain stunted and their leaves are bunched together at the top, forming a rosette and margins of the leaves become weary and slightly rolled upward. If the plant survives, it remains small, stunted and fragile and the extreme ends of the fingers of fruit formed become black[4].

The virus can only be transmitted by means of aphids which have previously fed on diseased plants. The common spreading away of disease is by aphis-infected suckers import.

The only control measure is eradication of diseased plants when and wherever they occur. These should be destroyed by burning and all future plantations should be from certified bunch top free at any cost.

(3) **Sigatoka Disease.**—It is not less important than any other disease of Banana. But fortunately it is not as widespread in Indo-Pak, as in Tropical America, Australia, Honduras and Guatemala.

It is caused by a specific oragnism called Cercospora musae. As a control measure, the wider spacing of plants had been recommended[3]. Sanitary measures such as removing and burning of infested leaves and plants, should also be adopted. Frequent spraying with Bordeaux mixture is also recommended.

(4) **Main Stalk Rot.**—This diseaseis caused by a species of Gloeosporium. This trouble is of the Banana fruit bunch. A brown to darkbrown patch from the central point of the marked curvature of the main stalk indicates the beginning of this disease. This drying and blackening travels downwards to fruits. The affected parts get shrivelled and dried as a result of this disease.

Bourgandy mixture spray once a fortnight is very effective when the fruit is young[1].

(5) **Anthracnose.**—The fruit may or may not be attacked by this disease when it is on plant. Fruit is attacked more frequently after harvesting during transportation.

It is caused by a fungus Gloeosporium musarum Cooke and Massee and is found

in all countries wherever Banana is grown. The diseased fruit shows small, round black specks. In severe cases large brown zone covers the entire fruiting. Bananas, affected in this way ripens earlier, prematurely and finally turns black and rots.

The Banana variety named Gros Michel is said to be very resistant to this disease.

Since disease becomes virulent on harvested crop, to minimize damage fruit should be handled in a way that there is no bruising and is transported between the temperature range of 51.8 to 53.6 F.[4]

ACKNOWLEDGEMENT

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BANANA CULTURE IN PAKISTAN

BY

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Horticulturist, Government Fruit Farm, Mirpurkhas

PAKISTAN'S POSITION IN WORLD PRODUCTION

BANANA occupies a place of great prominence in the fruit wealth of Pakistan. It is reported that out of an estimated annual production of 25,35,000 metric tons of fresh fruits in Pakistan banana alone accounts for 14,13,000 metric tons *i.e.* 55 per cent of the total production. World production of banana is estimated to be 94,56,000 metric tons and of this 15 per cent is contributed by Pakistan, 21 per cent by India and 39% by Brazil, thus Pakistan is the third largest banana-producing country of the world.

AREA AND DISTRIBUTION

It occupies an area of 92,854 acres constituting 26.6% of the total area under fruits, in Pakistan. As much as 95.7 per cent of this area (88,800 acres) is located in East Pakistan. The acreage in West. Pakistan is only 4,054 acres which is mostly confined to the Khairpur and Hyderabad divisions (3,845 acres). In rest of the divisions it is very nominal *viz.* Peshawar division 5 acres D.I. Khan division 73 acres, Bahawalpur division 31 acres and Karachi Administration 100 acres. In East Pakistan it is extensively grown in the districts of Dacca (10,250 acres), Rajshahi (9,500 acres), Rangpur (8,350 acres), Mymensingh (8,000 acres), Faridpur (6,500 acres), and Khulna (6,350 acres). In rest of the districts the area under banana is less than 5,000 acres each.

LOCAL NOMENCLATURE

In East Pakistan, the banana is called as Kela in Bengali, and in West Pakistan it is known as Kelo in Sindhi, Mauz in Urdu, Mekrani, Pashtu and Punjabi. However, all over West Pakistan now the name Kela is in common usage.

QUALITATIVE CHARACTER AND DIETIC VALUE

The fruit is soft and sweet and staple food for thousands of people, in tropical areas and a rare luxury in Europe. It is very popular because of its very pleasant flavour and high nutritive value. It is a good source of food energy, minerals and vitamins. It is said to surpass all fruits and vegetables including potatoes in energy value and tissue-building elements. Banana yields 30,000 to 70,000 lbs. per acre of land, which is much bigger than the average yield of any food crop, because of which it enjoys its position as the only staple food for millions of natives in the Pacific, Atlantic and tropical islands. It contains 15 to 20 per cent sugar which is a rich source of energy. Banana is a fair source of minerals, especially potassium, calcium, magnesium, phosphorus and chlorine. Banana contains vitamin A in fairly large quantity and vitamins B, G and C in appreciable quantities. It is recommended as a reducing diet for the obese and as a nutritive food for the infants in Hawaii[6]. It is reported that an excellent cider can also be prepared from banana[6]. Apart from the fact that ripe bananas make an ideal diet, even the green bananas make excellent dishes when employed in culinary arts. Green bananas are said to be a better source of vitamins than the ripe ones. The cooking varieties can be dehydrated and made into powder for use as flour like that of cereals.

Bananas are also preserved as banana figs. They are simply dried from ripe fruits, peeled and split lengthwise, in halves, placed on trays and dried in the sun.

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Bananas are also preserved as banana figs. They are simply dried from ripe fruits, peeled and split lengthwise, in halves, placed on trays and dried in the sun.

PLACE OF ORIGIN AND WORLD DISTRIBUTION

The banana is said to be indigenous to Malayan Peninsular, or its neighbourhood or in tropical forests like those of East Pakistan. Now its cultivation has spread to many countries in the world, such as Jamaica, Mexico, Guatemala, Brazil, Costa Rica, British Honduras, West Indies, Indonesia, Cambodia, Viet-Nam, India, Malaya, New Zealand, Spain, Italy, and Portugal.

The industry is highly specialised in Guatemala under the management of the United Fruit Company with an acreage of 125,000 hectares. It is the biggest banana farming company in the world with a rail road system of its own running in the plantation and a fleet of 100 ships specially built for banana export.

PLANT CHARACTERISTICS

Banana is a herbaceous non-branching plant varying in height from 6 to 20 feet. Its true stem is the underground rhizome, the pseudostem being formed of the bases of leaves. From the centre of the pseudostem emerges, the inflorescence which is an elongated spike. The flowers are arranged in clusters of two spiral rows each, and are of three types. Those at the base of the spike open first and are pistillate, towards the end of the spike are neutral and staminate flowers. In the neutral flowers the pistil and stamens are underdeveloped. It has two sets of roots, one set spreads in the top two feet, horizontally, while the other set grows vertically even to depth of six feet where the conditions are favourable.

CLASSIFICATION

Banana is closely related to the Ginger and Canna families, and belongs to the natural order Scitamineae genus Musa. All the edible varieties which can be eaten raw without resorting to cooking, have been classed as *Musa sapientum* on the basis of cytological studies by Cheeseman at the Imperial College of Tropical Agriculture Trinidad. The plantains, which can be eaten only when cooked, are classed as *Musa paradisiaca.* The other species of Musa which are of economic importance, are *Musa textillis* the Manila hemp which is largely exploited in Philippines island. Another species *Musa basjoo* is used in Japan, for manufacture of course fabrics. Both stem and rhizomes are used as food, in case of an African species, *Musa ensete*.

VARIETIES

A brief description of the cultivated varieties of Pakistan is given below :—

(A) THE VARIETIES OF BANANA GROWN IN WEST PAKISTAN

1. *Mirpuri* : (Synonym Basrai of Bombay, Harichhal, Maurltius, Mons Marie in Australia, Kabuli, and Nepali of East Pakistan).

Originally introduced from Bombay, acclimatised and selected at Mirpurkhas, Government Fruit Farm, from where it has now spread to many districts of Hyderabad and Khairpur divisions, and other places in West Pakistan.

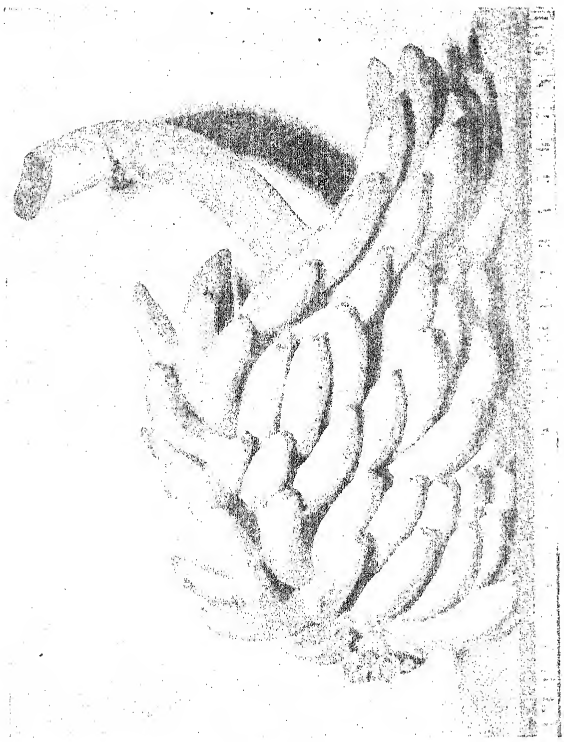
The stem is dwarf, 5′ to 6′ in height. The leaves are broad. The fruit is large curved, skin is greenish, even when ripe flesh soft and sweet. Keeping quality poor. Average weight of bunch varies from 20 to 30 lbs. A good bunch weighs 60 lbs. The average number of fingers varies from 8 to 10 dozens. The best bunch at Fruit Farm has yielded 223 fingers.

This variety is best suited for dry climates and windy situations due to its dwarf stature. It is a leading variety of the former province of Sind.

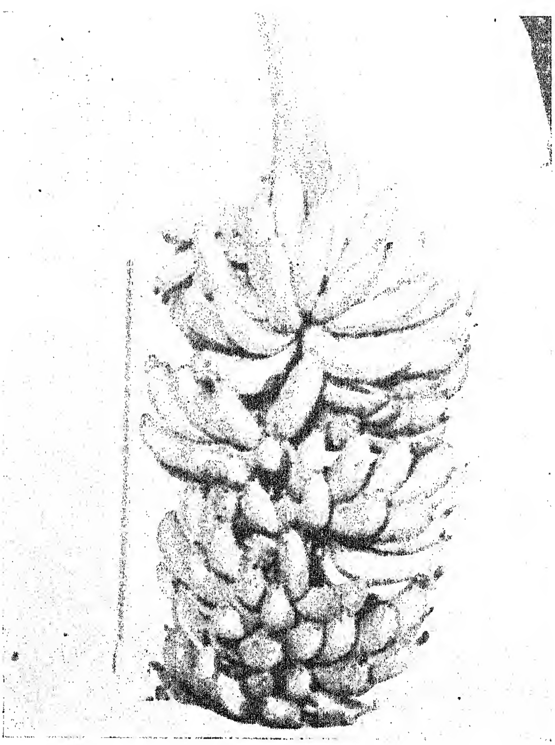
2. *Sonkel* : (Synonym Mutheli of Bombay, Martaman of East Pakistan).

The plant is tall, slender, with sparce leaves and reddish tinge on the margins of peduncles and suckers moderately ; the fruit is of medium size, rounded, thick and stout, skin is thin and has shining ivory yellow colour when ripe. The colour of the unripe finger is glossy green, and the top is not prominent. The pulp is white, firm and delicious in taste. Bunches are small and each weighs 20 to 25 lbs. The fruit has a good keeping quality.

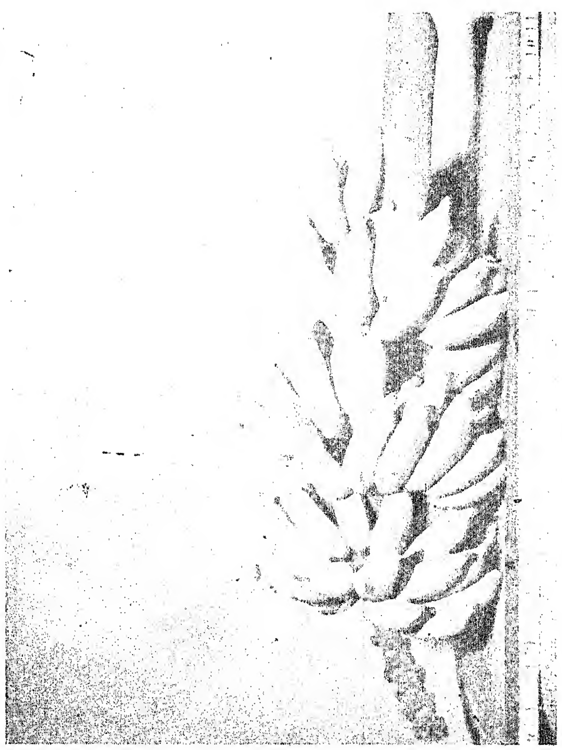
3. *Nadan Pacha* : Plant is semi-tall. Bunch is fairly heavy. Fruits angular and big sized with thick rind, and blunt apex. Pulp is white soft, and sweet. Keeping



BASRAI

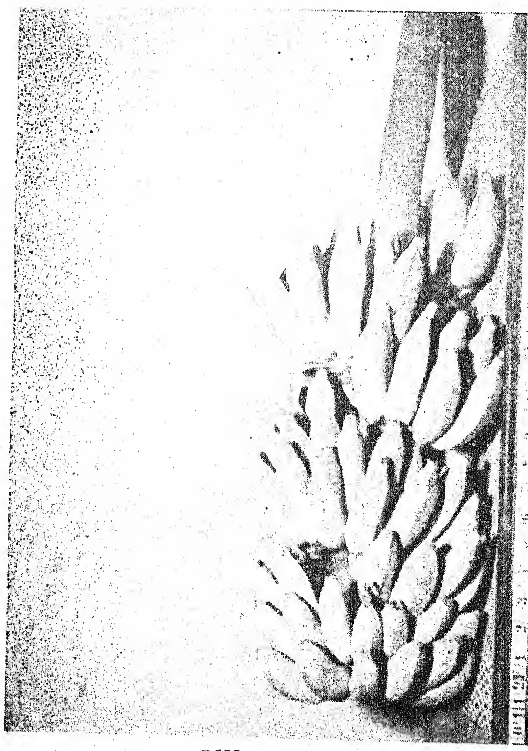


BASRAI (Mirpuri)

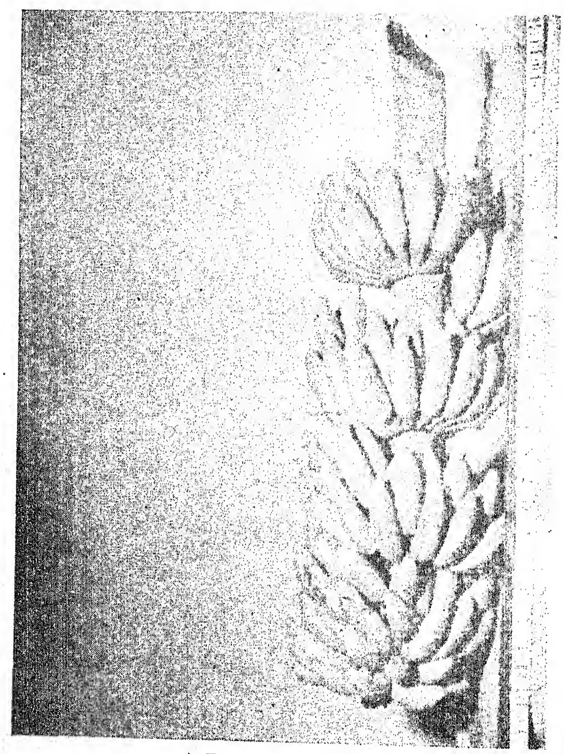


SONE KEL

A bunch of Pedda Pacha



PHILIPPINE



A Bunch of Soneri

quality is good. Rind colour, on ripening is greenish yellow.

4. *Pedda Pacha* : Plant is of medium height and taller than Mirpuri. Petiole margins are spread out. Fruit is big sized, slightly angular and curved. Rind colour is light green when ripe. The pulp is creamy white soft buttery, and tasty. Seed core is prominent.

5. *Rajeli* : Robust tree with yellowish green stem and long narrow leaves. Stands partial drought. The fruit is big sized. 8 to 10 inches long and 1 to 1½ inch, in diameter. Yellow in colour when ripe. Hard brown, contracted beak. Rind is thick, bunch not compact. Pulp is orange yellow, firm and has characteristic taste.

6. *Elchi* : Synonym *Velchi, Soneri.* Tall variety, suckers moderately, stem slender, light green in colour. Bunch is medium large and pendant, fruit glossy green when unripe and ivory yellow when ripe. The rind is papery. Pulp is firm, white and rather dry. It has a good keeping quality. The bunch contains 7 to 8 dozen fingers and weighs 13 to 15 lbs. It takes about 14 months to flower, and two and a half months to develop fruits ready for harvest.

7. *Philippines* : It is a very tall growing variety. Basal portion of the pseudostem is prominently green and thick. Bunch is pendant, almost compact, and heavy bearing. Finger rind is thick and green and yellow when ripe, pulp is creamy white. A bunch contains 10 to 12 dozens of fingers, and weighs 15 to 20 lbs.

8. *Salam* : Tall plant. Bunch is pendant, heavy and spreading. Fingers are thick long and angular in shape, and are light green even after ripening. The rind is thick. Taste is good but flavour lacking. Each bunch gives on an average six dozen fingers weighing about 15 lbs.

9. *Rasbale* : Plants tall and slender colour of the pseudostem is brownish. Leaf midrib prominently pink, on both sides. Bunch is pendant, compact and heavy bearing. Fingers are angular and green and yellow when ripe. Rind is thick. Pulp is sweet but dryish. It has a good keeping quality. The plant yields 9 to 10 dozen fingers to a bunch which weighs 13 to 15 lbs.

10. *Rajapuri* : Synonym Walha of Bombay. Dwarf stem, fruit short and thick, near the stalk, and tapering towards the apex. Ridges are distinct on the fingers. The variety is medium good. Pulp is stringy in the centre.

11. *Hazara* : Plant very tall with a heavy thick pseudo-stem, dark green in colour. Fruit bunch is pendant, fruit is thick long, and robust. Heavy bearing. The rind is thicker and yellow when ripe. Pulp is white and sweet in taste but poor in flavour. Mostly used as a vegetable. The plant is partially resistant to cold spells.

(B) THE VARIETIES OF BANANA GROWN IN EAST PAKISTAN

12. *Safri* : Safri, one of the two best dessert bananas of East Pakistan is grown in all parts of the province and is known as 'Malbhog' in Rangpur and Dinajpur and 'Anupan' in Rajshahi. The fruit is absolutely seedless. Finger is straight to curved and medium long. Pericarp is straw-yellow ; pulp soft, malleable, sweet and delicious.

13. *Amritsagar* : Amritsagar, one of the two best dessert bananas of East Pakistan, is particularly met with in the Rampal areas of Munshiganj Subdivision, Dacca. The Government of East Pakistan considers this to be the best variety from point of view of quality and production. The fruit is seedless ; finger is oblong, falcate and long. Pericarp is lemon yellow ; pulp sweet, scented, soft, melting and delicious.

(14) *Champa* : Champa is grown quite extensively and a great majority of the areas under banana cultivation is covered by this dessert variety. The fruit is almost without any seed. The finger is somewhat short ; pericarp is bright lemon yellow ; pulp soft, malleable, sweet but slightly acidic.

(15) *Agniswar* : Agniswar is grown to a very limited extent. The name might have originated from the reddish pigmentation of the pericarp. The fruit is seedless,

finger is oblong, slightly curved and medium agreeable, soft and melting pulp.

(16) *Dudhshar* : Except the colour of the pericarp which is greenish yellow the size of the fruit, its taste and quality are almost identical to Agniswar. This is also very rarely grown.

(17) *Kabri* : The Kabri, though an inferior table-variety is commonly found in the homestead gardens and is popular amongst the poor. It has different names, such as, Madhua, Jinkala, Shail, Shamong, Bargle, Bhat, etc. The fruit occasionally contains a few seeds, finger is oblong and almost straight, medium long, pericarp dull yellow, pulp sweet, aroma not so agreeable.

(18) *Singapuri*: This is an introduced banana and is not largely cultivated in the province. This banana has been known under the names of seedless finger Jahaji, Kabuli and Nepali also. This is a superior dessert banana, seedless with finger oblong, falcate and long. The pericarp is green to greenish yellow. The pulp is sweet, with a negligible aroma. The bunch is very big.

19. *Kachkela* : There are a number of types of kachkela, the name signifying banana used in unripe stage, as a vegetable. This is worth giving to the patients after ailments owing to the easily digestible nature of the fruit. The fruits are stout and medium long to long. The pericrap is greenish yellow to light yellow when ripe, pulp dull in sweetness, somewhat pasty and poor in table quality.

(20) *Aita Kela* : All the seeded bananas, such as Jhawa, Shangi, Botur, Bhim, Gona Pati, etc., come under the group Aita. Fruits belonging to some of the varieties are exceedingly large in size, while others are medium, but almost all broad in diameter. The pericarp is light yellow with coppery specks in most varieties, the fruits are full of seeds, pulp sweet but somewhat pasty.

In West Pakistan, Mirpuri is the most popular variety and in East Pakistan Amritsagar and Safri are the most distinguished.

In the adjoining states of India, Sonkel Velchi, Basrai, Lalkel and Rajeli are considered to be the choicest varieties of Western India, while Pooven is very popular in the Madras ; Champa and Murtaban are the commercial varieties in Northern parts of India.

Of all the edible bananas, Gros Michel is a variety of great importance in the world market. It is also called as Jamaica or Blue fields. Its excellent quality of taste, heavy production, superior shipping and marketing abilities have earned for it a place of distinction. It is a tall tree with long slender yellow fruit. Next in importance is the cavendishi banana principally grown in Canary and Hawaii islands.

CLIMATE

Banana flourishes well in warm, moist weather which should be available throughout the year. Its growth is found to be luxuriant in warm humid and rainy climate of the tropical regions, on both sides of the equator. The long spell of rains from April to November in East Pakistan, and the proximity to the sea, provide an ideal climate for the growth of banana. Long dry season, yearly frosts in the Northerly regions and hot dry strong desiccating winds in Southern areas, have been responsible in checking the development of banana industry in West Pakistan. The hot winds blowing throughout the Indus Plains, during the summer, cause shreading and drying of the leaves. The low temperatures during the winter, severely check the growth of the crop, and in severer colds the crop is damaged. The leaves of the affected plants, turn yellow, get crinkled and dry out. The normal functioning of the leaves is seriously affected resulting in the emergence of poor fruit bunches and low yields.

Mirpuri (Basrai) has a great future in West Pakistan. It has a characteristic adaptability for areas with scanty rain and dry and windy climate. The climate of Mirpur where it was originally acclimatised is summarised below :—

The mean yearly maximum temperature is 88.8 and minimum 70.65°F. The mean highest temperature in summer is 108°F and 44°F the mean lowest in the winter.

The mean humidity is 76.6% and average rainfall is 7 inches.

The climate of lower Indus valley comprising the Karachi Administration, Hyderabad and Khairpur divisions, is sub-tropical desert type. Aridity is the commonest feature. Thermal equator passes through this region. It has a desert in the East, sea in the South, mountains in the West and Punjab plains in the North. Sky is usually clear, the frost is a rare feature. Low pressure area is caused at Jacobabad, owing to high summer temperature. The mean maximum temperature is 113°F. Mean humidity is 40 per cent and diurnal range of temperature is 45°F. Sea breezes reach inland upto 100 miles, wind velocity is 15 miles per hour. Prevailing wind is Northerly or North Westerly, in Winter, Southernly or South Westerly in summer. Rainfall is scanty averaging 7 inches in south and 3 inches in the north. Except in the extra peninsular Morgain Western High the Kirthar Mountains and Kohistan section. The desert areas of the Pat and Thar sections, the rest of the Indo-Gangetic plain of lower Indus valley, western and eastern sections and the deltaic areas are climatically best suited for the Mirpuri bananas.

The areas on the river bank in other parts of West Pakistan are also suited for this variety where frosts are rare.

SOIL

Banana needs a rich, well-drained soil with plenty of organic matter. Hilly soils with shallower depths of 1 to 1½ feet are unsuitable, for want of retentiveness and enough space for the root development. Badly drained clay soils or those with hard pan below are also not suitable for banana cultivation, because of the bad drainage. The light sandy loams of the coastal tracts, the deep alluviums of the riverine the new alluviums of the river banks and the deltaic soils are all suitable for banana cultivation. Deep laterite soils of the moist hilly regions are also suitable. Sandy and medium soils are more productive than heavy clays. Heavy, ill-drained and shallow soils make the banana susceptible to panama, a disease caused by Fusariuum oxysperum varicubence. Heavy loams of the wet paddy lands are also suitable for this crop. Saline soils having more than 0.05 per cent salinity is dangerous for banana.

PROPAGATION

Bananas are universally propagated by suckers. There are two types of suckers (*i*) The sword type and (*ii*) the broad-leaved sucker. The sword sucker has a vigorous shoot and is thick at the base, converging towards the apex with few linear leaves. These arise mostly while the parent plants are young. The broad-leaved suckers have wide leaves, right from the beginning. The sword-leaved suckers are preferred to the latter and it is believed that the broad leaved suckers have already dissipated their stored energy in the development of leaves and they are supposed to give poor yields. Mostly the broad-leaved suckers arise when the parent pseudostem is removed. Careful selection should be made of good suckers for planting as they influence the future plantation and the yield. They should be from parents of outstanding merits, such as high yield, uniform bunch development with a good sized bunch and fingers. Suckers should be less than 3 feet in height and form healthy mature plants. Large suckers are not preferable though these give early yields, as the bunches are poor from such suckers.

The sucker should be dug out and separated from mother plant with a sharp broad chisel, causing the least possible injury to the mother plant. On its removal the old roots over the bulb of the sucker should be removed. If these are immediately planted, new leaves and roots make their appearance within a week or so. For distant despatch, the pseudostem of the suckers should be headed back severely and only the corms may be bundled and sent by rail etc. The numerous swollen buds on the surface sprout and make their appearance on planting.

In the Hyderabad division, the suckers are headed back to about two-thirds original length. Their roots are cut back severely and then they are dipped in thick paste of cow dung and water. This process is supposed to protect the suckers from rapid drying in the open field until they sprout.

Gandhi[5] (1957) reports that Basrai is propagated by dormant rhizomes in East

Khandesh. The suckers are encouraged to grow freely on the residual moisture after the parent plantation is cut down. When the suckers are a foot or two high they are dug out from the old plantation and their pseudo-stems completely cut back to the solid bulb and their roots are removed. The bulbs weighing from 1 to 2 lbs. are stored in cool dry place for about two months under the shade of a tree. During the resting period the bottom remains of the banana fibre fall off leaving the heart bud prominent. Only the conical rhizomes which have a sound heart and side buds are selected.

Age of suckers seems to influence the yield. Experimental evidence obtained in West Bengal shows that better yield is obtained by planting 3 month old suckers than younger or older during September October season.

In Central America and West Indies bits or sections of rhizomes are employed for propagation. Each bit contains at least one bud. Good results are reported with 8 lbs. bits.

SITE FOR PLANTING

Bananas should be planted as far as possible in protected areas. Exposure to strong winds should be avoided. Protection should be provided against strong winds by planting a wind break on windward side. For dwarf varieties like Mirpuri, (Basrai) a temporary wind break of shevri (Sesbania egyptica) is recommended on the south and west sides of banana plantation. The seed of sheveri (Jantar) should be sown in double rows 10 to 15 feet away from 1st row of banana to avoid competition in the intake of nutrients and moisture. In permanent locations tall growing shisham should be planted as a windbreak.

PREPARATORY TILLAGE

The land should be thoroughly prepared by deep sowing 4 to 6 times, followed by clod crushing and levelling each time. All weeds should be removed. In West Pakistan where the cultivators have to depend on irrigation water, flat beds should be prepared having an area of at least 1/80th of an acre (½ a gunta). In this province the problem is of water retention while in East Pakistan the problem is draining of excess rainy water. Hence the cultivation of banana in East Pakistan is found to be on raised beds with channel in between for drainage.

Pits should be dug 2 feet deep and 2 feet wide in diameter, at a given spacing, for a particular variety. The dug soil may be left for withering for 15 days to a month and mixed with well rotted farmyard manure at the rate of at least half maund per pit, before incorporating the soil back in the pit. After filling in of the pits, the beds should be irrigated once or twice so that the undecomposed portions of manure may rot well before planting.

SPACING

The distance of planting varies according to the height and spread of banana variety in response to the climatic and soil conditions in a particular locality. The recommended distances and the number of plants required per acre are given below:

Sr. No.	*Variety*	*Distance in ft.*	*No. of plants per acre*
1.	Mirpuri	6	1210
2.	Sonkel	8	680
3.	Nadan Pacha	6	1210
4.	Pedda Pacha	6	1210
5.	Rajeli	8	680
6.	Soneri	8	680
7.	Philippine	8	680
8.	Salam	8	680
9.	Rasbale	8	680
10.	Rajapuri	6	1210
11.	Hazara	10	435
12.	Safri	9	538
13.	Amrit Sagar	8	680
14.	Champa	10	435
15.	Agniswar	9	538
16.	Dudshar	9	538
17.	Kabri	8	680
18.	Singapuri	7	889
19.	Kachkela	10	435
20.	Aita Kela	11	360

Spacing of 8 feet is suitable for inter-cropping with vegetables or green manuring crops, and for interculturing operations. Where the soil is rich and the climate humid, the spacing can be increased by a foot or two and where it is poor and the climate is dry, there closer spacing is advisable.

Broad leaved Sucker

Sword leaved Sucker

Different sizes of suckers used in planting

Young plantation of Banana

PLANTING

At the time of planting 9 inches deep holes wide enough to accommodate the lower corm of the suckers should be dug and the suckers planted. The soil should be well pressed around the pseudostem. In case only the bulb of the rhizome is to be planted ; the same may be done in holes 6 inches deep just to accommodate the bulbs.

TIME OF PLANTING

Time of planting varies in different places. In East Pakistan the plants are set out in April-May, before the onset of monsoon rains. In the lower Indus plains two seasons are recommended (1) February-March and August-September. February-March planting should be preferred as the plants have a fine spring to establish themselves, and to make speedy growth in the summer that follows the planting. The August-September planting is followed by dry winters hence the growth remains suspended, and the plants are exposed to the possible injury of low temperature and frost in their young stage. In coastal climate the planting can be done all the year round. However, planting done in Autumn months, receives a setback because of the onset of low temperatures. This untimely check in the growth of young-plants is not helpful. Suckers planted on 20th February at Government Fruit Farm Mirpurkhas had commenced flowering in September in the same year after a period of seven months. Thus it is evident that plants make very rapid growth when planted in spring.

IRRIGATION

Because of very large leaves through which it transpires the huge quantities of moisture, the water requirements of banana are very heavy. Recommendations vary with the local conditions, natural vigour of plants, variety etc. Sandy porous soils which drain out water faster and become dry, need more frequent irrigations than the clayey soils which retain water for a longer time. In hot summers water is transpired more rapidly from leaves than in cold winters hence frequent watering is needed in summer than in winter. Similarly a banana plantation with large number of plants per unit area would need water, at shorter intervals than that with spareer plantation.

In the southern areas of West Pakistan, bananas are irrigated every week in summer, and in winter at an interval of 10 to 12 days. The irrigation interval may be modified or adjusted in different tracts according to the availability of moisture. No irrigation is needed in rainy days. In East Pakistan where the rains begin in late spring and last up to November, followed by occasional showers, irrigations do not become necessary. In dry arid climate of Indus plains the frequent irrigation is a necessity. Experimental evidence obtained at Government Fruit Farm, Mirpurkhas, shows that higest yields are obtained where the plants receive weekly irrigations throughout their growth. Irrigation intervals of 10 days or 14 days considerably lower the yields.

MANURING

Banana plant reaches a height of several feet in a year's time and produces gigantic quantity of leaves and fruits. Therefore it is necessary that the soil from which it draws its nourishment must be very rich in readily assimilable nutrients to make possible this rapid growth.

B. Boulfil of Guinea states that for every 30 tons of fruits, 30 tons of wood and 30 tons of leaves are produced by banana. Thus in one growth cycle it has been estimated, on experimental evidence that 250 lbs. N ; 60.8 lbs. of P_2O_5 ; and 597.3 lbs. of K_2O are removed per acre by this crop. Nitrogen is necessary for early development, and phosphate acts beneficially in the early stages of plant growth and fruit formation. Potash helps in increasing the yield, its quality and its resistance to diseases. Following doses of fertilizers have been recommended when applied singly:

(*i*) 900 to 1350 lb/arce Ammonium Sulphate.

(*ii*) 1250 to 1800 lb/acre super phosphate.

(*iii*) 700 to 1100 lb/acre sulphate of potash.

Due to the paucity of adequate experimental evidence, uniform recommendations

for banana in Pakistan do not seem to be advisable. The data collected so far at Mirpurkhas show that higher yields can be obtained by an application of 50 cartloads of F.Y.M. (each cartload 800 lb) per acre, at the time of planting followed by a top dressing of 100 lb N per acre in the form of ammonium sulphate. The top dresser should be applied in two equal doses. First dose 3 months after planting and the second dose during the eighth month of growth.

Manuring practices followed elsewhere in the banana production centres are summarised below to give a fair idea about variability of the practices according to local conditions.

Basrai bananas are given a generous dose of 50 tons (140 card loads, each weighing 800 of F.Y.M. per acre in East Khandesh (India) before planting suckers are planted in July 5 feet apart. Four plants form a bed. About 70 irrigations are given for manuring a crop, in addition a dose of 0.4 lb. N is given per plant in two doses either in the form of groundnut cake at the rate of 2 tons per acre, or with part replacement with Ammonium Sulphate.

In West Bengal, each plant is given 30 lbs. of silt, 2 lbs. of mustard cake, the process is repeated after 4 months.

In Bihar, 1 lb. of N per plant is said to be desirable, along with 0.27 lbs. P_2O_5 and 2 lbs. K_2O.

Application of 8 oz N per plant is reported to hasten the fruiting and to increase the yield in Bengal.

Gandhi (1957) reports that Basrai is capable of yielding 50,000 to 60,000 lbs. per acre, if 40 lbs. of F.Y.M. is given to each plant as a basic dose at the time of planting and 5 lbs. of cake applied as top dressing. The top dresser is divided in 3 doses, 1½, 1½ and 2 lbs. each given in the second, third and fourth month after planting respectively.

Equally high yields are reported to have obtained in Basrai banana in Khandesh, by applying 80 lbs. F.M.Y. per plant as a basic dose.

In wet lands of Tamilnad the manuring practices consists of the application of 20 lbs. F.Y.M. at the time of planting followed by top dressing, 3 lbs. groundnut cake, and 1¼ lb. of ammonium sulphate per plant in 2 doses at an interval of 2 and 3 months after planting.

In Gaugawaram (India) the plants receive 4½ lbs. groundnut cake, and 1½ lb. of ammonium sulphate per clump.

The popular manuring practice at Godaveri delta is reported to be as follows:—

(1) 224 lbs. Ammonium sulphate per acre, in April-May two months after planting.

(2) 1000 lbs. of groundnut cake and 224 lbs. of Ammonium sulphate in the 5th or 6th months.

(3) 224 lbs. of sulphate of Ammonia in the 9th month.

At Bassein (India) the manuring practice is yet quite different. Each plant receives the following mixture :—

Castor cake	4 — 5 lbs.	per stool
Sulphate Ammonia	1½ lb.	per stool
Sulphate of Potash	10—11 oz.	„
Super Phosphate	11—12 oz.	„

Three to four applications of the mixture are given at a regular interval of one month after planting.

In absence of the authentic data on the utility of other ingredients the present recommendations based on experimental evidence at Fruit Farm, Mirpurkhas be adopted by banana growers in West Pakistan :

(*i*) 50 cartloads of F.Y.M. (800 lbs. each) per acre at the time of planting.

(*ii*) 100 lbs. N in the form of ammonium sulphate/acre as a top dressing in two equal doses three months after planting and 7 months after planting.

The top dresser should be spread around the base of the plant in an area of about 2 feet radius and thoroughly mixed in the soil and should be followed by irrigation invariably.

INTERCROPPING AND COVER CROPPING

Banana requires at least 4 to 6 months to grow densely enough to make any undergrowth unthrifty. Hence inter-spaces can be employed for raising seasonal inter-crops

like onion, garlic, spinach etc. in autumn, and chillies, brinjals etc. in spring. Successful cultivation of these crops is possible in the first four to six months' growth of banana plantation. Afterwards they shade the crops heavily and the under-growing plants are not capable of making fruitful-growth. While raising inter-crops care should be taken to avoid deep rooted crops, that would be exacting in nature for nutrient requirements. Liberal allowance should be made at the time of manuring the banana crop for the inter crops to be grown, so that the main crop may not suffer for want of nutrients.

Cover cropping with guar or sunhemp in summer and berseem in winter is very helpful in production of good sized crop, when the cover crops are incorporated in the soil at full maturity. This practice is very helpful as it adds humus to the soil. These crops should be cut and incorporated in the soil with the spade etc. Experimental evidence obtained at Government Fruit Farm, Mirpurkhas shows that the practice of inter-cropping or cover cropping is very beneficial.

INTERCULTURING

Constant interculturing with spade etc., is very essential during the first 3 to 4 months for removal of weed if a cover crop or inter-crop is not grown to keep the weeds at their minimum, subsequent stirring of the soil at least once in two months is essential for maintaining the soil in good tilth.

SUCKER REMOVAL

Numerous suckers are produced during the lifetime of the mother plant. These suckers if left to themselves make rapid growth, at the cost of the main plant and seriously hinder its normal development. Hence regulation of suckers is one of the most essential operations in banana cultivation.

During my visit to East Pakistan, absence of suckers in most of the new plantations in Munshigunj area attracted my special attention. Enquiries made revealed that the cultivators are meticulously careful in brushing off the sucker growth, underneath the banana plants. The growers keep handy a sort of sickle for this purpose.

Where a single crop is taken, and no subsequent ratoon crop is desired, no sucker should be allowed to grow. This practice is prevalent in Basrai banana plantations in East Khandesh.

In case even a ratoon crop is desired, no sucker should be allowed to grow till the main plant comes into bearing. At the time of flowering of the main plant, only one sucker should be allowed to grow. By the time the fruit bunch is removed the sucker shall have made about 3 to 4 months vigorous growth, as a succeeding daughter plant.

In removing suckers, care should be taken to cut them off from the parent rhizome completely but with minimum of possible injury to the main plant. The object can be achieved by chiseling off the vegetative growth above ground by a short sickle (rhambi or khurpi), but the operation has to be repetitive and a constant vigilance is required. The practice followed at Queensland consists of cutting off the suckers few inches above ground, gauging out a small portion of central section with a knife, and pouring in a one-third tea spoon of kerosine. This could be adopted only when suckers are not at all required for new plantings or sale etc.

CROP DURATION

Soil fertility, the manuring practices and the varietal behaviour are the deciding factors for determining the number of years, the banana plantation should continue to remain on the same piece of land, year after year.

In the deltaic silt deposited lands perennial plantations are reported to be existing lasting over 50 years, as against this Basrai banana is raised for one crop only in districts of Gujerat and Khandesh in India (Gandhi 1957), and it is reported to deteriorate in yield and quality as a ratoon crop. The same variety which is acclimatised at Mirpurkhas, has peen observed not to deteriorate even for three succeeding crops. Hence the best principle is to take the crop in the same land year after through sucker generations till the quality and yield are found to deteriorate. In the normal circumstances it seems possible to continue the banana in the same area at least for three years.

PROPPING

With the full development of fruit bunch the banana plant needs support to save it from total uprooting. Even the bunch itself may snap off if proper support is not given in time. This operation of supporting bananas with bamboo or otherwise is known as propping. It is very essential operation specially in areas subject to heavy winds else the entire crop ready for maturity and harvest, is likely to be lost. Propping may be done by double poles tied into a fork at the upper ends or by grounding the single stout poles on the lowered side about 8" to 10" away and lightly tying the pseudostem at two or three places.

PROTECTION AGAINST SUNBURN AND FROST

Due to the heavy weight of the bunch, the plant leans in the direction of the hanging bunch, sometimes exposing the bunch to the scorching rays of the sun, and thus subjecting it to the sun scald injury. Therefore it is necessary to protect the bunch by thatching with banana leaves or unserviceable old gunny bag pieces. The stalk of the bunch should also be protected against the sun scald injury else the development of the entire bunch is arrested.

In areas subject to frequent frost, the banana cultivation should be invariably done, in protected areas, surrounded by tall trees such as shisham, jaman etc. On the possible approach of frost the plantation should be flooded with water, and heavy screens of smoke should be created by burning trash in between and all round the plantation.

REMOVAL OF INFERTILE FLOWER SPIKE

At the end of the elongated spike, the large heart-shaped foral portion, containing infertilised flowers enclosed in reddish scales, persists even after the pistillate flowers have developed into fruits forming a bunch. This persistent portion should be removed, soon after the fingers have developed else, it is likely to draw its nourishment, which otherwise would be utilized by the developing fruit. Removal of this portion, after 13 days, after the development of the fingers above, is said to improve the appearance of the bunch and increase its weight by about two pounds.

COVERING OF BUNCHES

Ordinarily bunches are not covered during their development in this country. But in Australia the developing bunch is covered with plastic covers. It is said to improve the weight and quality of fruit and to hasten the maturity. Blue, red and yellow coloured plastic covers are employed for satisfactory use. The covers protect the fruit against chilling in winter, scorching in summer and from splitting of fingers, attack of pests and exposure to micro-organism.

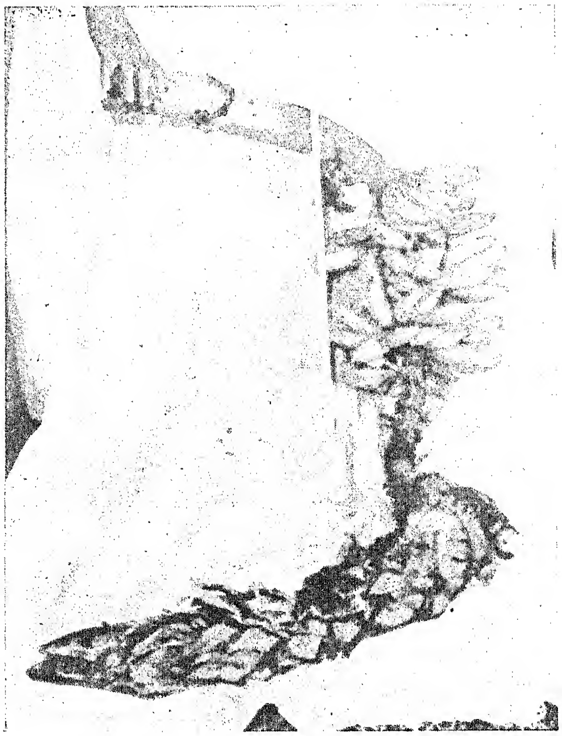
FLOWERING AND FRUITING

Plants start flowering in 8 to 12 months from the date of planting, depending upon the variety and growth conditions of the plants. A further period of 3 to 4 months is required for maturing a crop. Bunch maturity is indicated by full development of fingers, evidenced by plumpiness and rounding off their angles and change of colour of the fruit from deep green to light green. The whole bunch is harvested by cutting its stalk at least 12 to 18 inches above the first basal fingers. Care is taken to avoid sap from the cut stalk staining the fruit.

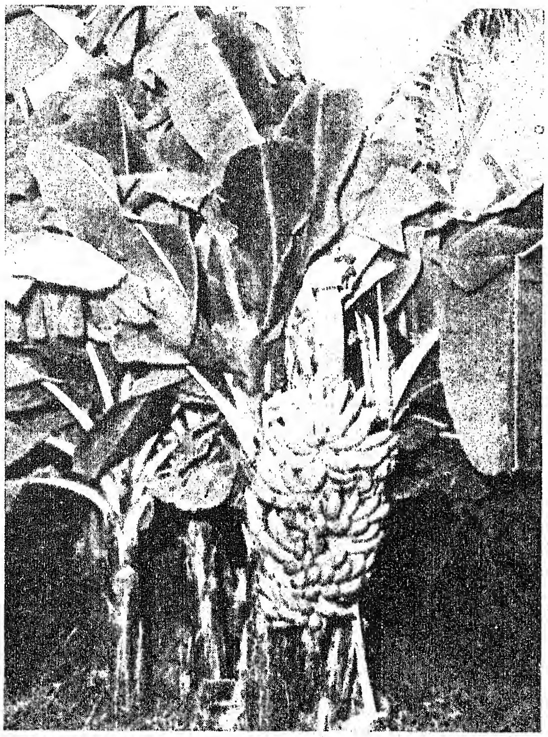
YIELD

The yield of banana varies with variety, cultural practices, and the soil and climatic conditions. In East Pakistan with the most favourable soil and climatic conditions, 417 maunds yield is obtained per acre, whereas in the Bahawalpur and Peshawar divisions it is reported to be 125 maunds, 100 maunds respectively, while in the former province of Sind the yield varies from 100 maunds to 450 maunds depending upon the variety. The number of days taken for maturing crop and the yield per plant of different varieties is tabulated below :—

Variety	To reach maturity in months	Wt. of bunch lbs.	Yield/ acre in mds.
Mirpuri	14 to 15	20 to 30	450
Sonkel	14—16	10—15	125
Nadan Pacha	13—16	5—10	150



A banana bunch with persistant male flower



Basrai bunch ready for harvest

Variety	To reach maturity in months	Wt. of bunch lbs.	Yield/ acre in mds.
Pedda Pacha	14—15	5—10	150
Rajeli	15—16	4— 8	100
Soneri	14—16	10—15	125
Phillipines	15—16	10—15	125
Salam	14—16	15—20	150
Rasbale	16—17	10—16	140
Rajapuri	14—15	10—15	250
Hazara	17—18	20—30	250
Safri	11—13	13—22	150
Amrit Sagar	9—12	18—26	220
Champa	9—11	17—29	200
Agniswar	12—15	7—12	100
Dud sar	12—15	6—10	150
Kobri	12—16	15—29	200
Singapuri	8—10	25—38	350
Kacha Kela	12—15	21—32	300
Atia Kela	15—20	30—36	350

SEASON OF PICKING AND MARKETING

Although plant bears throughout the year, the peak production is confined to the summer months from March to October. Production goes down considerably during the winter months.

Mirpuri is in greatest demand in West Pakistan, and is usually marketed under the name Harichhal. Bananas with good shape inviting appearance and characteristic flavour are in maximum demand. Desi varieties having a sticky flesh, hard core and skin adhering to the flesh edible portion even when ripe are not liked for table purpose. The popular market varieties of East Pakistan are, Champa, Amrit Sagar, Dud Shar, Sabri and Martaban. Kobri and Atia are seedy varieties and are not in much demand.

In East Pakistan, the bunches are carried in bulk, no system of packing is adopted, when sent to long distances the bunches are wrapped in dry leaves. The Amritsagar and Dudsagar are however transported in bamboo baskets.

In West Pakistan the fruit is packed in crates, which are usually employed for malta (26″ × 12″ × 12″). The hands are separated from the bunch, and are carefully filled up in the crates, which is stuffed alround with the dried leaves and paper etc.

The standing crop is usually sold to the contractors, and then entire crop is handled and marketed by these contractors.

RIPENING OF BANANA

Bananas packed in crates take about 6 days to ripen and change to attractive colour, in summer and about 8 days in winter. Where ripening is to be speeded up, bananas are packed in crates stuffed with green banana leaves or green leaves of siris (Albeza labek).

When huge quantities of bunches are handled, the curing is done by heaping them under the cover of dry leaves, and treating them with a slow burning smoke, of dried cowdung cake and straw in an almost airtight room, for a duration of 24 hours in summer and 48 hours in winter. These fruits change from deep green colour to light green or yellow, and are further stored for a 3 to 4 days in well ventilated rooms before final disposal.

While small quantities are handled, the hands are separated from the bunch and heaped in a corner of a room. The heap is covered with dry leaves and old gunny-bags. The entire heap is plastered with mud leaving a space sufficient to accommodate the bottom portion of the earthen jar, near the surface. A hole is bored in the bottom of the jar and is so placed as to face the hole towards the heap and the mouth of the jar is facing outside. Through this mouth, dried pieces of cowdung cake and dried leaves are fed, and lighted for slow burning and passing the smoke so created in the heap. This process lasts for two days and nights in a closed room. The bananas turn yellow and are then spread in the room for further curing for another two or three days, before final disposal in the market.

Bananas immediately consumed after removal from crates or heaps etc., do not taste well and give a burning flavour. They need to be cooled in ventilated rooms at least for 12 to 24 hours before they give their characteristic flavour.

COLD STORAGE

Bananas do not stand low cold storage temperatures. Hence green bananas should never be kept in frigidaires and refrigerators. The low temperature retards their ripen-

ing and blackens the fruit rendering them unfit for consumption. Experimental evidence obtained at Poona shows that green Basrai bananas can be kept at 68°F for 3 weeks, to ripen them slowly to attractive colour. It is necessary that similar experimental data should be obtained for varieties grown in Pakistan at different centres.

At times, complaints have been received during winters specially from Lahore consumers, to the effect that the bananas never ripened, even after 10 days in the crates sent to them. The Mirpuri variety gets chilled, even at 56°F and never ripens, hence, during periods of low temperatures, the fruit crates need to be kept in warm places, where they would receive more than 75°F, for proper ripening, and a humidity of not less than 70%.

PESTS AND DISEASES

1. Root stock borer: A weevil *cosmo pilites sordidus* is seen to attack the banana rhizome. The weevil spends its life in the rhizome, grubs bore it and weaken the plant. The pest can be controlled by (*i*) spraying with D.D.T. thrice at an interval of 15 days after the attack (*ii*) placing of small heaps (around the plants) of thins sections, of pseudostems and rhizomes dusted with paris green, brings the pest under control. (*iii*) A mixture of eldrine and dieldrine, placed around each plant also controls, the pest. (*iv*) Even placing of 50 grams of 25% B.H.C. in a ring round the plant destroys the pest.

2. A weevil *Adoiporus longicollis* attacks the pseudostem. It is controlled by destroying the affected suckers. The ill drained spots provide the best conditions for the onslaught of this pest. Hence well-drained situation should be selected for planting the suckers.

3. A fruit and leaf beetle, *Nodostoma subcostatum viridipinis* spoils the appearance of fruit and impairs the flavour. Beetle appears in early summer, causes heavy damage by early autumn, and disappears in March. It feeds on young leaves which are about to emerge. Clean cultivation and spraying with D.D.T. brings the pest under control.

4. Panama disease : It is a wilt disease caused by a soil-borne pathogen *Fusarium oxysporum var. cubense.* Champa and sonkel are reported to be susceptible. The symptoms of the attack consist of yellowing and drying of leaves, followed by withering of the entire pseudostem, the infected fruit becomes bottle-necked and mature unevenly.

The name Panama is current due to the fact that it was first recorded in Panama in the year 1903 and was found to destroy huge plantations in Panama and Costa Rica.

The ill-drained soils and waterlog situations provide congenial conditions for the disease and hence such situations should be avoided. Remedial measures do not exist. Hence care should be taken to obtain suckers from disease free plants.

Breeding of resistant varieties has been done at Imperial College of Tropical Agriculture, Trinidad, and a variety named I.C.I. has been evolved which is resistant to disease and nearly as good as Gros Michel.

The varieties grown in West Pakistan seem to be all resistant to the disease. Of these Mirpuri is highly resistant.

5. Main stalk rot : This is a disease of the fruit bunch and is caused by the species Gleoesporium and Bortyodiplodia. The disease appears as a dark patch on the central curvature of the fruit stalk. The blackening and drying spreads downwards to the fruit. A reddish, brown colour develops on the fruit. The skin begins to dry and turns greyish, and small crackings are noticed. The cracks grow larger and deeper. The disease can be controlled, by spraying with burgandy mixture 4 lbs. copper sulphate, 5 lbs. washing soda, 50 gallons of water.

6. Bunchy Top : It is a virus disease. Symptoms : Leaves of badly infected plants are bunched together at the top forming a rosette. Margins of the leaves are wavy and slightly rolled up. The infected plants remain conspicuously stunted. The basal part of the young leaf shown through transmitted light, dark green streaks broken in dot and dash manner along the mid rib. Susceptible varieties—Basrai and Champa.

Control : Destruction of affected plants.

7. Leaf spot : It is also called as Sigataka and is caused by Cercospora species,

It can be controlled by spraying 4 : 4 : 50 Bordeux mixture.

8. Young and green fruit is primarily attacked by anthracnose, caused by Gleoesporium muserium finally causing the rot of ripe fruit, Bordeus mixture, spraying checks the disease.

9. Black tip or finger tip, rot of the immature fruits is caused by the species of Bortryodiplodia.

10. Streaks on leaves and fruits are caused by Maerophoma musae.

The diseases so far described above are yet not prevalent in West Pakistan. Growers need to be on the look, out as the plantation is likely to be extensive, in the near future. On noticing an unhealthy condition of plants caused due to pests and diseases, growers should report the same to the plant protection officers of the Department of Agriculture in their respective divisions, who shall take necessary measures to bring the trouble under control.

EXPENDITURE AND INCOME

The growers in this country are not in the habit of keeping accurate records of income and expenditure of the orchard crops grown by them. Hence it is very difficult, to give a correct appraisal of the situation in different localities. Since Mirpuri variety is now in great demand in West Pakistan, the estimated expenditure based on factual data at the Fruit Farm Mirpurkhas is given below :

EXPENDITURE STATEMENT

July, 1957 to June, 1958

	Items of expenditure	*Quantity*	*Rate* Rs. As.	*Amount* Rs. As.
1.	Irrigation ...	1 man	1 12	1 12
2.	Ploughing etc.			
	(*a*) Tractor ploughing ...	1 hour	16 0	16 0
	(*b*) Tractor clod crushing ...	1 hour	16 0	16 0
	(*c*) Disc ploughing & levelling ...	1 hour	16 0	16 0
3.	Preparation of beds and channels ...	20 men	1 12	35 0
4.	Digging pits ...	48 men	1 12	84 0
5.	Cost of Manure & its carting ...	12 trucks each weighing 50 mds.	20 0	240 0
6.	Manuring ...	24 men	1 12	42 0
7.	Irrigation ...	1 man	1 12	1 12
8.	Cost of suckers ...	1,200	1 0	1200 0
9.	Planting ...	6 men	1 12	10 8
10.	Irrigation ...	1 man	1 12	1 12
11.	Subsequent irrigations ...	48 men	1 12	84 0
12.	Top dressing with ammonium sulphate	500 lbs.	10 6 per bag	51 14
13.	Spreading & mixing top dresser ...	16 men	1 12	28 0
14.	Supporting bunches ...	10 men	1 12	17 8
15.	Weeding & hand-hoeing 6 times during the year	90 men	1 12	157 8
				2013 10

JULY, 1958 TO JUNE, 1959

	Items of expenditure	*Quantity*	*Rate* Rs. As.	*Amounts* Rs. As.
16.	Chaukidars one during day one during night	2 men	52 8 per month each	1260 0
17.	Removal of suckers for sale ...	30 men	1 12	52 8
18.	Manure ..	12 trucks	20 0	240 0
19.	Manuring ...	24 men	1 12	42 0
20.	Top dressings ...	500 lb. A/S	10 6 per 100 lb.	51 14
21.	Spreading & mixing the top dresser...	16 men	1 12	28 0
22.	Irrigations ...	48 men	1 12	84 0
23.	Weeding and hand hoeing ...	90 men	1 12	157 8
24.	Supporting bunches ...	30 men	1 12	52 8
25.	Harvest & sale of fruit ...	10 men	1 12	17 8
				1985 14

JULY, 1959 TO JUNE, 1960

(Partly and estimated expenditure)

			Rs. As.	Rs. As.
26.	Manure ...	12 trucks	20 0	240 0
27.	Manuring ...	24 men	1 12	42 0
28.	Weeding & hand-hoeing ...	90 men	1 12	157 8
29.	Irrigation ...	48 men	1 12	84 8
30.	Top dresser ...	500 lb. A/S	10 6	51 14
31.	Top dressing ...	16 men	1 12	28 0
32.	Supporting of bunches ; 800 bunches	40 men	1 12	70 0
33.	Removal of suckers ...	30 men	1 12	87 8
	Total ...	...	...	720 14

STATEMENT OF EXPENDITURE AND INCOME IN RUPEES

Year	*Expenditure*	*Income*		*Profit and Loss*
1957-1958	2013 10 ...	...		−2013 10
1958-1959	1785 14 ...	Sale of suckers	1700 0	+6714 2
		Sale of fruits	7000 0	
			8700 0	
1959-1960	720 14 ...	Sale of suckers	3000 0	±13779 2
		Sale of fruits	11500 0	
	4720 6		14500 0	18.479 2

Yearly income from one acre is Rupees 6,159-14 per year.

Note.—Chaukidars were not employed by the Farm Administration duing 1959-60 as the crop was sold to the Contractor.

PROSPECTS OF BANANA CULTURE IN WEST PAKISTAN

From the foregoing account of the area and production it is evident that the area under banana is very negligible in West Pakistan and consequently its production. The demand of banana fruit of the consumers in West Pakistan cannot be met by the growers in East Pakistan in spite of the fact that exportable surplus exists in that wing. The main handicap is of transport of bananas from East to West Pakistan. The little quality of banana that is transported by air, is too costly for the consumers here. Transport by sea is out of question as the fruit does not stand ordinary cold storage, and the ships plying are too few and too far in between. R.M.S. Aronda, is the only passenger ship plying between the two wings, but its journey around is only once a month. The cargo ships take about 15 days to reach Karachi from Chittagong, hence even if the fruit is sent in the open deck cargo, it cannot stand the period and deteriorates by the time it reaches Karachi port.

In foreign trade, bananas are shipped from the producing centres to the consuming European countries through ships exclusively built for this purpose. The holds of the ships are insulated and trunkways are constructed in the holds where thermometers are fitted for recording temperatures at regular intervals. The holds are subdivided into compartments called bins, 30 sq. ft. each. The banana is held in these bins. The temperature in the holds is regulated by passing the outside air which is cooled over brine pipes situated in a special house in the upper deck, the same is passed to trunkways by large fews. The temperature of holds is maintained at 37°C throughout the journey. Vessels with such an equipment do not exist in Pakistan and hence transport of banana from East to West Pakistan is not easy of solution.

In the circumstances stated above, the demand of banana in West Pakistan shall have to be met from local production. Non-availability of good quality banana plants, scorching summers, high winds, and frosts have remained the limiting factors so far. But with the successful acclamatisation and introduction of the Mirpuri banana (originally Basrai of Bombay) which is suited to dry rainless tracts, the problem stands resolved.

It is hoped that the information placed in the hands of growers through this bulletin would serve as an incentive to the growers to proceed, with its extensive cultivation, with confidence and foresight and thus bring prosperity to their door steps.

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BANANA CULTIVATION IN PESHAWAR AND DERA ISMAIL KHAN REGIONS*

By

MIAN SAID, M.Sc. (Pb.)

BANANA is one of the most ancient, delicious and valuable food plants having been used and perhaps cultivated with the dawn of the recorded history. Its native place cannot be located with assurance, but the plant is said to have originated from South-West Asia and therefrom spread all over the tropical countries. It is supposed to have reached the Western world in the beginning of the 16th century. It is generally agreed upon that all edible bananas and plantains are indigenous to the warm, moist regions of tropical Asia, but its largest production today is found in the West Indies and tropical America, where it forms an important industry.

Banana is a very valuable plant. Its fruit is excellent in taste, wholesome and easily digestible. It is rich in carbohydrates and minerals in addition to vitamins A, B and C in fairly good proportions. The inflorescence is used for making vegetable and the leaves for fodder, the pseudostem is used for fibre and the rhizomes of certain species are used as food. All these uses show that few other plants are so useful as the banana.

BOTANICAL CLASSIFICATION

Banana belongs to the genus Musa of the family Scitamineae. The common edible forms are usually classed in three species. The tall varieties with fruits edible raw are called *Musa sapientum*, while those (Plantains) which are edible when cooked are *Musa paradisiaca*, but according to the latest work of Cheesman, banana and plantain have been botanically classed as otherwise. There is no dispute however with regard to the dwarf banana which is universally known *Musa cavandishii.*

DISTRIBUTION

A very large number of banana and plantain varieties are grown in East Pakistan along the coast. It is also grown as stray plantations to an elevation of several thousand feet in West Pakistan where it is thus subject to a very wide range of climatic conditions. In the region of Peshawar and D. I. Khan inferior varieties are grown in Haripur (Hazara District), Charsadda (Peshawar District) and Bannu District. As a matter of fact these three places along with Dargai area (Malakand Agency) have got a large scope for banana culture especially with inauguration of the irrigation projects.

Preliminary work on the improved types of bananas was started at Haripur Agricultural Farm by the introduction of the following six varieties from East Pakistan in March, 1951 :—

1. Amrit Sagar.
2. Singapuri.
3. China Champa.
4. Agniswar.
5. Dhud Sagar.
6. Safri.

SOIL

It requires a deep and well-drained soil irrespective of any special importance to its physical condition. Banana is an exhaustive crop, hence the fertility of the soil is of utmost importance. It should either be sown on a very fertile soil or the land should judiciously and regularly be manured. It is a good practice to remove the plantation after 10—15 years and give chance to such other crops which halls

*Thanks are due to M/s. Abdul Ahad Dar and Sher Ahmad Khan for their respective assistance in conducting varietal trials and quantitative tests.

restore the fertility of the soil. Good drainage is also essential.

CLIMATE

Some of the varieties can stand several degrees of frost without any marked damage to them. The most favourable climate is the one with warm and moist weather throughout the year and without strong winds. In the north there are three main reasons which inhibit its extension and these are a long dry season which necessitates frequent irrigation, cool winters which are adverse to so many varieties and hot and dry winds, which dry out the foliage. It thrives best where plenty of water and sun-shine are available.

CULTURE AND PROPAGATION

Except in experimental breeding, propagation is invariably by vegetative means. The most common form is that by the use of suckers, which arise in large number from the parent rhizome. These are of two types one with long narrow leaves and the other with broad leaves. Usually the former is considered superior. These should be removed when 2—3 feet high. For removing the suckers from the mother plant the earth is dug slowly on all sides. A sharp and steady cut is thus given at the joint of the two and the sucker detached is planted in the desired place after removing the expanded leaves from it.

The suckers can be planted at any time, except during winter and dry summer months, provided irrigational facilities exist.

SPACING

Generally, the dwarf varieties are placed at 8—10 ft. and the tall ones 14—20 ft. The imported varieties at Haripur Farm were planted with rectangular system in the first instance at 15 feet distance in rows 20 feet apart. In November, 1951 suckers from the mother plants were planted in the same rows making the plants 7½ feet apart. Similarly in April, 1952 another lot of suckers from the same mother plant was planted in between the rows which reduced distance between rows from 20 to 10 feet. From the last four years of experience it is proved that close plantation is desirable under our conditions in order to protect the fruit from sunburn during hot weather and also because less frequent irrigations are required. Windbreaks are very essential especially for the tall varieties like China Champa.

PLANTING

Pits two feet deep and 2 feet wide may be dug and filled with good soil and fine well rotten manure. Sometimes trenches are also made for planting bananas to ensure quick and efficient irrigation and drainage.

IRRIGATION

Banana seems more sensitive to water deficits than most of other orchard species. Ample irrigational facilities all the year round should therefore be ensured before its plantation is undertaken. The frequency of the irrigations may vary with the physical condition of the soil and climatic condition. Under Haripur conditions it requires irrigation after every 3-4 days in summer and once a week during winter.

Regarding irrigational system the plantation was irrigated by basin system in the start but it was observed that the plants were not happy with this system. So the plantation was divided into small well levelled plots and irrigated by flood system and the health of the plants was remarkably improved.

MANURING

Banana is a gross feeder and requires judicious application of manure almost everywhere for its normal growth. Nitrogen is its main requirement and its demand for potash and phosphorus, if at all any, is very little. In the rich alluvial soil like ours, banana is most apt to be grown in now; only nitrogen has been found deficient for bananas and frequent application of nitrogen has become the general practice on all such soils. Some soils may be too acid to allow frequent use of ammonium sulphate. High nitrogen requirement in banana planting is mainly due to its considerable loss by leaching and by soil organisms associated with the purification of vegetable material, such as banana leaves etc.

The plant also seems to be actually a high nitrogen plant. A very high nitrogen

supply does not prevent the plant from fruiting, but rather tends to make the bunches larger. The commonest practice is to give it a dressing of manure farmyard or cowdung. The following doses have been applied at the Haripur Agricultural Farm with good results :—

1. 160 lbs. of well-rotten F. Y. M. per stool.
2. 80 lbs. of F. Y. M. plus one pound of ammonium sulphate per stool.

The pseudostem after removal of the fruit bunch is cut into pieces and spread round the stool, for manuring. If this process is regularly practised, the requirement for additional manures will be comparatively less.

TILLAGE

There is seldom any need of hoeing to the plantation when it properly develops as weeds find it difficult to grow under its shade.

VARIETIES

As already stated, poor varieties were growing in Haripur Tehsil and Bannu District. Considering the shortage of good banana fruit after partition it was felt worthwhile by the Department of Agriculture, North-West Frontier Province, to introduce improved varieties from East Bengal. In 1951 seven suckers each of the following six varieties were therefore imported and planted at Haripur Farm:—

1. Amrit Sagar.
2. Singapuri.
3. China Champa.
4. Agniswar.
5. Dhud Sagar.
6. Safri.

Observations and data of these varieties regarding their stature, hardiness to hot dry winds and winter frosts, suckering habit, plant performance, weight per bunch, number of fingers per bunch, size of the fingers, curing and keeping quality and resistance to disease were recorded.

From the point of view of growth all these varieties did well throughout the summer months but frosts in winter greatly damaged the varieties, namely Amrit Sagar, Agriswar, Dhud Sagar and Singapuri. The former three varieties were the most sufferers. Only China Champa and Safri varieties could resist the frost. In December, 1954 these could withstand a temperature as low as 29° F. The two varieties unfortunately are tall growing and are badly affected by heavy wind storms but this damage can effectively be checked by providing wooden supports and wind breaks.

In case of Amrit Sagar and Dhud Sagar the plants are dried by frost up to the ground, but by cutting the damaged portion in spring, the suckers again come out from the rhizomes. These two varieties have not given any fruit so far and therefore in the spring of 1956, all these varieties except China Champa and Safri will be shifted from the Haripur Farm to Banana Nusery at Bannu.

On the basis of the four years' experience on banana culture at Haripur, a 10 acre banana nursery farm at Bannu was established in 1953. The climatic conditions at Bannu are very congenial for banana culture, as winter frosts are not commonly and severely experienced. In Spring 1955 a consignment of 1400 banana suckers from East Bengal was imported for plantation at the farm. This lot contained new varieties such as Champa, Sabori, Kabori and Agniswar in addition to the ones already discussed. At Bannu the China Champa variety again was the first to come into bearing. The rest of the varieties have now started blooming and first hand information on their performance will shortly become available. With all the experience so far in respect of the varieties, the culture of China Champa and Safri is recommended under the present conditions at Haripur and Bannu District. China Champa variety is improving in its taste, flavour, fruiting capacity and size of the fruit bunch and fingers. Normally its bunch weighs from 20 to 30 lbs. bearing 120 to 160 fingers. The size of the finger is $4\frac{1}{2}''$ to $2\frac{1}{2}''$. Same is the case with Safri variety. It is hoped that by giving due share of attention to the cultural practices, these two varieties would successfully establish under these conditions.

The table on next page shows the quantitative and qualitative analysis of the recommended varieties of Banana.

	Qualities	China Champa	Safri
1.	Moisture	25%	22%
2.	Total solids	75%	78%
3.	Brix of finely pressed portion	24	22
4.	Refractive index of the above	1.365	1.362
5.	Appearance of the edible portion	Deep yellow	Light yellow.
6.	Smell Aroma	Peculiar Banana smell which is very pronounced on opening the fruit.	Fair Fruit Smell.
7.	Taste	Taste resembles that of an imaginary food banana which is increased on slow chewing. Rather soft to teeth, Texture being reasonably soft.	Texture not so soft, less sweet and more starchy as compared to China Champa. No hard core under Haripur conditions.
8.	Skin of the fruit	Deep yellow in colour soft and thin and easily detached from the fruit.	Slightly deep yellow in colour, slightly hard and comparatively thick.

PRUNING

The only pruning required by banana is with regard to the selection of its suckers, besides the removal of dried and diseased parts of plants. This operation is necessary to ensure a regular supply of fruit. All the rest except two healthy suckers are removed along with a small piece of rhizome attached to each. The two suckers left are of different ages. One is about half the age of the main plant and the other half the age of the first one. When the main plant is cut after harvest of the bunch the first sucker replaces it and this process continues. Under our conditions pruning may be so arranged to avoid fruiting in severe winter months as such fingers are generally poor in quality and size.

HARVESTING

Banana takes about a year and half to come into bearing. Its production during some particular period of the year is heavy otherwise it fruits all the year round except during severe winter months. At Haripur farm the harvest production is during June and July.

The bunches are harvested when the fruit is fully mature. The maturity of fruit on the plant is very essential to ensure finest flavour and taste. This is indicated by the fact that the fruit attains its full size length and diameter and changes colour from deep green to lighter green, with a yellowish tinge. The bunch has to be cut and handled carefully so that the fruit are not bruised as this will cause black spots. The bunch is hung in a warm room for a few days time and the fruits ripen themselves. If the weather is cold the colour can be improved placing the bunch in the sun during the day and hanging in a warm room at night; sometimes artificial ripening is also done by covering the bunches with "Darek" or "Sirin" leaves.

It takes 4-8 days for ripening of fruit in Darek leaves depending on the temperature of the locality.

Suckers that start high on the rhizomes, nearer the surface of the soil should be removed as they are easily broken by wind storms. The yield of fruit varies with varieties, soil and climatic conditions and cultural practices. China Champa on an average yields 175 maunds of fruit per acre.

DISEASES AND PESTS

Many are the diseases and insects that attack banana plants in different parts of the world but only the more important of these are described below.

FRUIT ROT

This is caused by the fungus Gleco-sporium musarum. Infection takes place when the fruit is young and green, but no

damage is evident until the fruit ripens. It can be controlled by spraying with Bordeaux mixture at the time of opening of the hands. Spraying should be handled carefully in order to avoid bruising otherwise the fungus will find its way into the fruit, causing rot and black spots.

STEM ROT

It is a serious disease causing much damage to the young plantations. The pseudostem of the newly planted sucker turns black and decays with the ultimate death of the plant. The simple control measure is to cut the pseudostem before planting and dip the rhizome in 2% copper sulphate solution for 10 minutes.

The main stem rot is also caused by some fungus. The first symptom is usually the appearance of a black spot on the upper surface of the fruit stalk just at the point of the curvature. The affected portion is damaged and dried up. The disease extends upward to the bunch and downward to the pseudostem. The rot weakens the stem and is easily blown up. Spraying with Bordeaux mixture once a fortnight when the fruit is immature, has been found effective.

ANTHRACNOSE

A species of the fungus Glecosporium is responsible for this disease. The tips are affected first which turn black and then rest of the fruit turns yellow and finally black in the permature stage. No control measure has been found but spraying with Bordeaux mixture as a preventive measure is suggested.

Other diseases are Panama or wilt disease caused by soil borne fungus and Bunchy top caused by virus. Prompt removal of the plants is the only remedy. Planting material should always be secured from an area free from these diseases.

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Sweet Lime	...	0	50
Peaches	...	1	00
Jaman seedling	...	0	50
Falsa	...	0	25
Grape	...	0	25
Grape-fruit	...	1	25
Kaghzi Lemon (seedlings)	...	0	25
European Lemon	...	0	75
Loquat	...	1	00
Pomegranate	...	0	50
Apples (small)	...	0	50
Pears	...	0	75
Khatti or Kharna Khatta	...	10	00 per hundred (If less than 100 paisas 0.13 per plant)
Khatti (for hedge purposes)	...	10	00 per hundred (If less than 100 paisas 0.13 per plant)

NOTE :—(1) Life Members of the Board are entitled to 5% discount on these prices.

(2) Packing charges of paisas 0.25 per plant will be extra.

(3) Last date for receipt of orders for plants is 31st July and 31st December for Monsoon and Spring seasons respectively. As a special case these dates can be changed.

(4) No order for plants is booked for which 25% advance money is not received.

Please write to :—

The Honorary Secretary

WEST PAKISTAN CO-OPERATIVE FRUIT DEVELOPMENT BOARD LIMITED, LYALLPUR

BANANA CULTIVATION IN BANNU DISTRICT

BY
INAYAT ULLAH KHAN
Extra Assistant Director of Agriculture, Bannu

After the partition 1947-48 all the improved varieties existing in the market has vanished due to restricted movement from India to Pakistan.

Hence a necessity was arisen to fill up this gap. It was therefore decided by the Government of old N.-W F.P. to establish Banana Nursery farm at different suitable stations. In this connection 85 kanals and 11 marlas of land was acquired by the Agriculture Department of old N.-W.F.P. Due to the climatic condition the Banana cultivation in the Bannu (within five miles radius) was already existing and a great deal of local varieties are being produced every year.

The existing local varieties have many drawbacks, due to the same it could not be made so acceptable in the market except its size which has the main attraction otherwise the taste and the texture of the local one is not so good.

To replace these varieties the department introduced different varieties from abroad and multiplied it at Banana Farm, Bannu, and studied their different performances in our local condition. The following varieties were imported:

1. Kabori. 2. Sabori.
3. Safri. 4. Chini champa.
5. Champa. 6. Chuni.
7. Amrat Sagar. 8. Daud Sagar.
9. Bombay red. 10. Singapuri.
11. Basrai. 12. Karachi special.
13. Agni Sawar. 14. Agri Sawar.
15. Platinum Bombay.

All these above varieties were under study for the last five years. During the 1st three-years the following varieties were eleminated due to lack of resistance to frost in winter and heat in summer.

1. Amrit Sagar. 2. Daud Sagar.
3. Singapuri. 4. Bombay red.

The following varieties, could not be propagated amongst zamindars due to their less fruiting and under size of fingers and bunches. Moreover, they are producing seeds in fruit which is a bad quality.

1. Chuni. 2. Karachi Special.
3. Platinum Bombay.

The following varieties are being distributed amongst zamindars, due to their adaptation to local condition, taste and texture of the fruit, though their size is not as big as that of local one. The maximum size of the fruit is 4 inches and the minimum is 2 inches while that of local is 3 inches to 7 inches.

1. Kabori. 2. Safri.
3. Sabori. 4. Chini champa.

To solve the problem of the size of the fingers two varieties have recently been introduced to this farm namely Harichall and Basrai well known for size and other market qualities.

The suckers were planted in the month of October, 1959 and November 1958, respectively. The suckers have sprouted but so far no fruiting has started. The plants are well resisted to climatic condition.

Cultivation Practices:

Sowing time

Generally, the Banana sucker can be sown throughout the year except December, and January, subject to the availability of irrigation water. Anyhow the best time noted at this farm is ranging from the

month of March to May and August to September.

Spacing

The spacing between plant to plant is generally regularised by the size of the matured plant and the sucker producing capacity of the variety.

The space may range from plant to plant and row to row 10′×10′ and 10′×15′. The smaller the size the shorter will be distance between rows and plants. The population of plants per acre may range from 400-600.

Manuring

Due to the short period of life and quick growth of the plant it requires sufficient quantity of F.Y.M. up to the extent of 80 cart loads per acre in their regular intervals. Application of Ammonium Sulphate at the rate of 4 lbs. per group of 8-10 plants in two equal doses in the month of February and September, followed by hoeing with Yumes (spade).

Soil

Medium loam soil is required for its cultivation.

Irrigation

This is semi-aquatic plant and requires very frequent irrigation after about every week. The requirements may diminish in the month of December, and January or during rainy reason.

Picking of fruit

The grand growth period for the fruit is from March to June. The total period from the flowering to maturity of the bunches ranges from 2½ to 3 months. The fruit formation from the flower produced in the month of August and later on is delayed due to winter season and the maturity period is lengthened hence affecting on the produce during the winter season.

Generally, banana fruit can be had throughout the year.

Curing of fruit

There is no special scientific method involved so far, for the curing of the fruit. Locally the fruit (bunch) is wrapped by leaves of Persian lilac (Darek), Sirin and banana leaves and kept in a drum or a wooden box for a period of 5 days during summer and 8 days during winter.

General

Usually about 2,000 suckers are annually being distributed from this station. Moreover, the daily sale of cured fruit is also in progress throughout the year.

BANANA CULTIVATION AT CARNARVON (W. AUSTRALIA)

By
J. A. LAWSON, B.Sc. (Agric.)
Agricultural Adviser, North-West Division

THE banana is claimed by some authorities to be the first fruit ever used by man. Indeed, it is so widely scattered throughout the tropical countries of the world that it is very difficult to name its centre of origin. For centuries it has been regarded as one of the most useful fruits for treating patients with digestive ailments, and over the last few decades it has been recommended by doctors, particularly for infants. Although the protein content of bananas is low, the sugars of the ripened fruit are present in a most useful form, and the vitamin content, by comparison with other fruits, is of quite a high level.

The banana is actually a member of the order *Iridales*, that is, it is related to Irises, etc., and belongs to the family *Musaceae*. It has a tuberous underground stem or rhizome (erroneously known as a corm) and the above-ground "trunk" is actually a pseudo-stem composed of leaf sheaths. In most of the domestic varieties no fertilisation of the fruit takes place, and as a bunch emerges, three types of flowers are produced ; females at the top, then a number of hermaphrodites, and the remainder at the "tassel" end, males. The ovules of the female flowers form the fruits, which, due to the lack of fertilisation, contain no seeds.

Until recent years, the most important banana variety of commerce has been the Gros Michel (*Musa sapientum*), but this, due to its susceptibility to a fusarium wilt (Panama disease), is now losing popularity, and Cavendish types (*Musa cavendishii*) are being planted in most of the world's commercial growing areas.

In Western Australia, the only commercial area of bananas in production is at Carnarvon, and as will later be mentioned, they are grown in most unusual conditions by comparison with those in other parts of the world.

In 1947 an excellent pamphlet was prepared by the Tropical Adviser at the time, Mr. G. B. Barnett, and this was a useful handbook for earlier banana growers. Some agricultural practices have changed in recent years, and the following article contains present Departmental recommendations.

DESCRIPTION OF THE AREA AND OF THE INDUSTRY

Carnarvon is situated 612 road-miles north of Perth, just 98 miles below the Tropic of Capricorn, at the mouth of the Gascoyne River. The surrounding area is typical "semi-arid zone," with a rainfall of less than 9 inches per year, and vegetated principally with hardy drought-resistant shrubs and scrub trees, the dominant tree type being the Acacia. This is "sheep-station" country, with a carrying capacity varying from one sheep to 15 acres, to one sheep to 50 acres.

The mean variation of the rainfall is very high, and although the average may be 9 inches, the actual falls can be as low as two inches in any one year.

The area is favoured with an extremely mild winter climate, but summer can be somewhat trying, due to the constant high winds which blow during most afternoons; these are sometimes known as "Southerly Busters," and Carnarvon is said by some to be one of the windiest towns in Australia. Then, on occasions, during windless periods, temperatures of up to 120 degrees are sometimes recorded. The average relative humidity is surprisingly high (63 per cent.) probably due to the moisture laden nature of the southerly winds.

The banana plantations are situated on alluvial soils on the banks of the river, for a distance of 12 miles from the mouth, and

at the present moment there are 130 operative. Their size ranges from 4 to 100 acres, and, generally speaking, each block has frontage to the "A" Class Reserve on the river bank.

On the south bank of the river (where more than half the district's bananas are grown) the soil is a deep, fertile loam. North bank soils are principally sandy loams varying to loamy sands in some areas. Gully soils are usually clay-loams. Early soil analyses class the soils as being moderately supplied with phosphates, well supplied with potash, but poor to medium in nitrogen.

Since the first banana consignment did not leave the district until 1930, the industry is only of very recent origin. It has experienced periods of economic depression, but also in more recent years has known great prosperity.

Very few growers concentrate on bananas alone : during the winter period, "cut-of-season" vegetable crops such as runner beans, tomatoes and cucurbit crops (in that order of importance) are also grown, but of the district's total income the bananas still represent two-thirds.

Prior to the disastrous cyclone of March, 1960, the area planted to bananas was approximately 330 acres, and in the 12 months up to the date of the cyclone 85,600 cases (average weight 78 lb.) were produced. It is worth noting that the district's average production (almost 260 cases per acre) is approximately 100 cases per acre higher than that of the better districts of northern New South Wales.

All the bananas produced are transported to Perth for sale, but this market's requirement is actually only half supplied by the Carnarvon fruit. Severe competition on the Perth Metropolitan Markets is sustained from northern New South Wales and, generally speaking, the numbers imported exceed those of the Carnarvon product every year.

Banana sales are subject to considerable fluctuation, and over the past few years, average prices for top lines have varied from 1s. 8d. down to 8d. Needless to say, periods of over-production in northern New South Wales drastically affect the Carnarvon prices. (The total area in banana production in New South Wales at the present time is 33,000 acres approximately, compared with 11,000 in Queensland). Many Perth consumers believe (erroneously) that the imported bananas come from Queensland. In actual fact Queensland bananas rarely, if ever, find their way into this State.

Since irrigation is necessary in the Carnarvon area, production costs per acre are considerably higher than those in New South Wales, but the distance of the Eastern States plantations from the Perth market allows a more-than-healthy competition in favour of Carnarvon.

Many natural hazards have to be contended with by Carnarvon planters. Cyclones of varying intensity may be expected every four to five years ; the 1960 cyclone registered an intensity of up to 120 m.p.h., this being the highest on record for the district, and was most unusual in that the "centre" passed directly over the area.

Droughts drastically affected the supply of irrigation water in the sands of the river, and this subject will be dealt with in a later section. Three floods have been experienced in the past 10 years, but generally speaking, although they cause inconvenience, they do more good than harm.

Two or three winter frosts each year are not unusual, but these do not constitute a major hazard.

At the present time, indications are that bananas will continue to be the most stable crop of the district for many years to come.

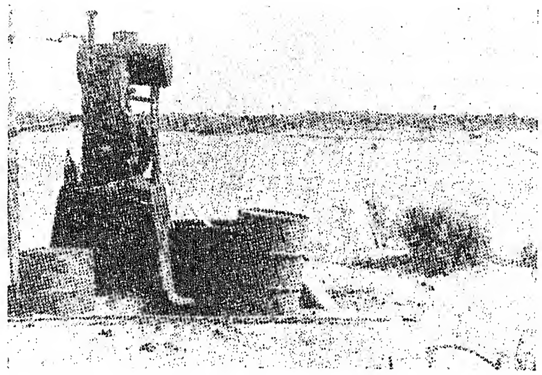
Plantation Layout

The majority of plantations, as mentioned previously, have access to river frontage. However, approximately half of the quantity of water being utilised at the present moment is pumped from the river sands ; and the remainder from bores and wells situated on the blocks themselves. Water is pumped from wells or bores by means of horizontal spindle centrifugal pumps of 2 to 4 inch outlet diameter, driven by diesel engines averaging 10 h.p.

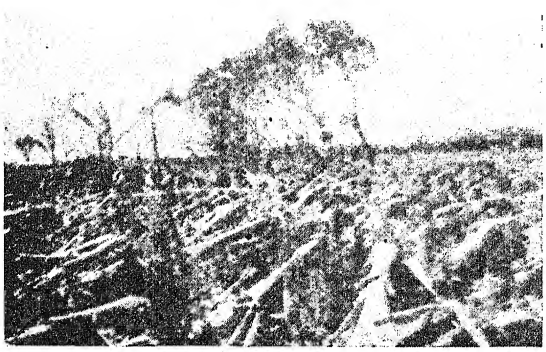
From the bore or well, water is pumped through pipelines to each section to be irrigated. It is usually discharged into a spill-pool from which run a series of cement drains. From the drains the water can be flooded out into bays or directed into furrows, depending on the nature of the crop.

Newly emerged banana floret

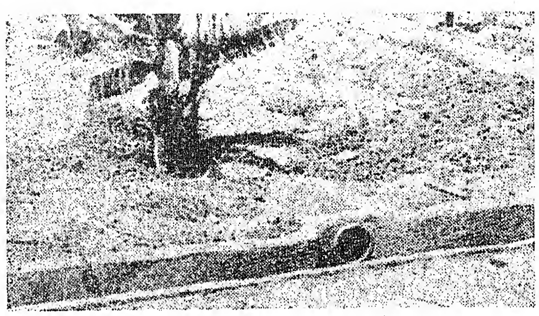
Gascoyne River Bridge during 1960 flood.
Height of bridge above sand level, 25 feet



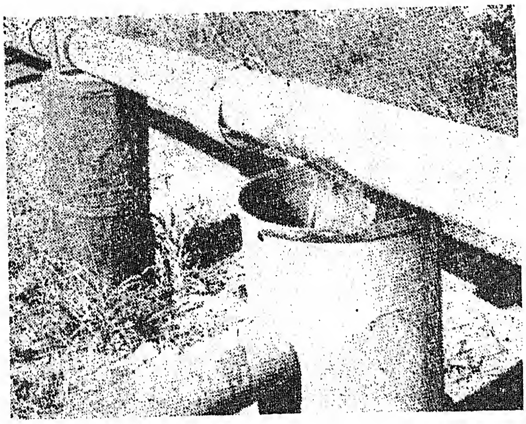
Typical river bank irrigation plant, pumping from surface sands



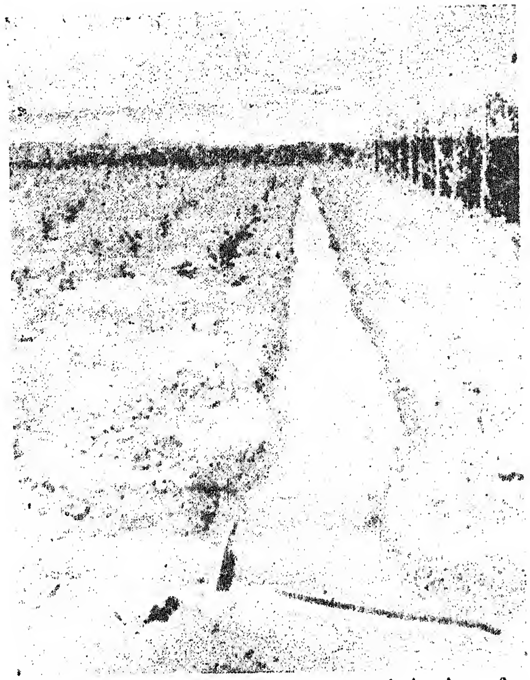
Aftermath of the March, 1960, cyclone



Typical cement irrigation channel showing outlet and "stop"

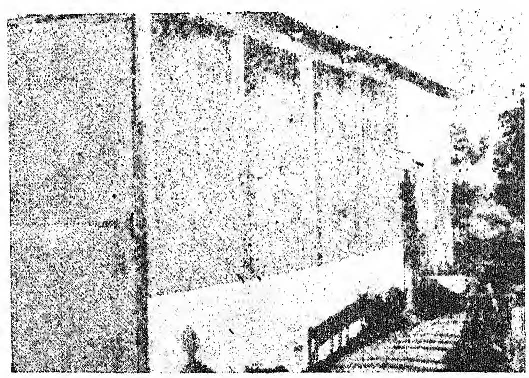


Fibrolite irrigation piping, showing support, outlet, clamp and "irrigator"



An "earth channel" being used for irrigation of a young patch. Thousands of gallons of water are wasted in such channels

An experimental irrigation system designed to reduce water usage. Each ¾ in. plastic hose irrigates three stools only, thus the entire bay is more rapidly filled, then hoses are easily dragged into the next bay. The pipe line is laid down the centre of the patch with the bays parallel to it



Packing shed with spinifex walls and roof sprinklers

Storage tank for irrigation water. An excellent aid to efficient watering

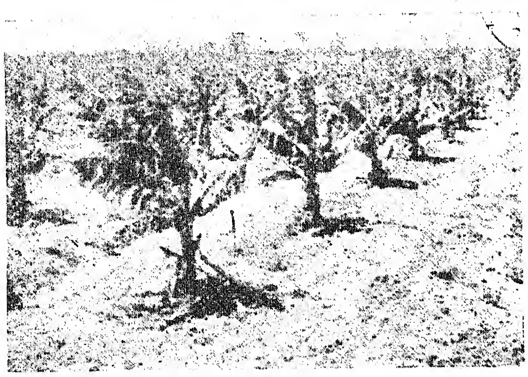
Throwing up the bank of a bay

Extreme "wide-planting"—A 9 ft. × 7 ft. carrying one sucker only

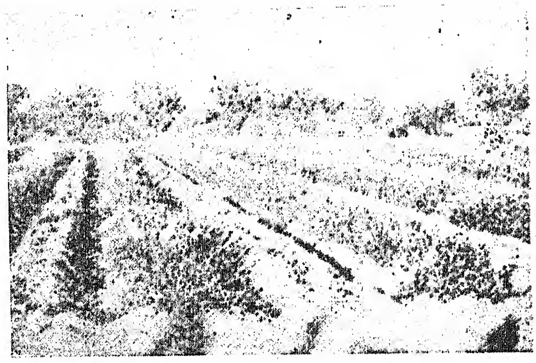
Polythene sheeting being used to reduce water usage. See also the weed growth outside the edges and the clean area covered by the sheeting

The "furrow" system of irrigating young bananas

The "close-planting" system. Newly planted suckers, showing double row in each bay



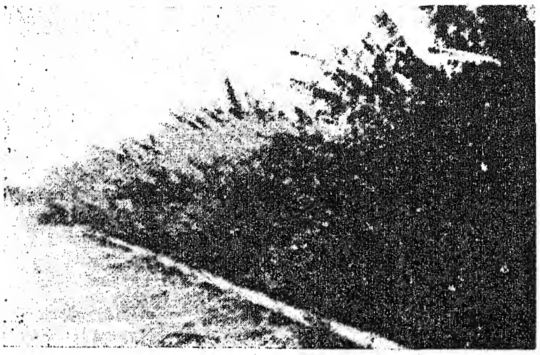
The "wide planting" system, showing parent plants. Three "followers" will be left on each parent



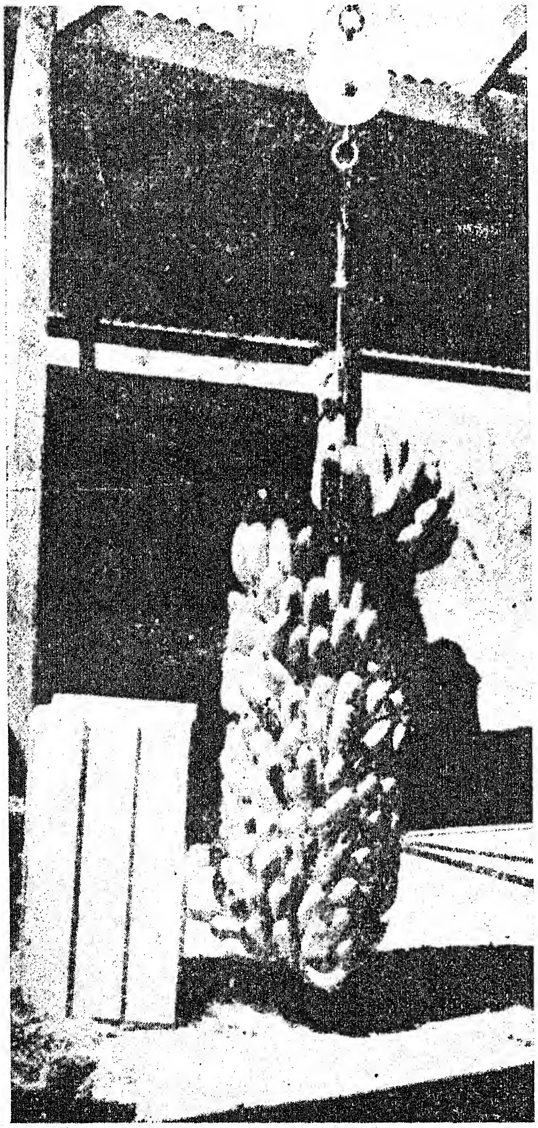
Uncontrolled weeds drastically reduce banana growth. The banks have been disced but the plants in the bays are scarcely visible

Planting a "spear-point" sucker

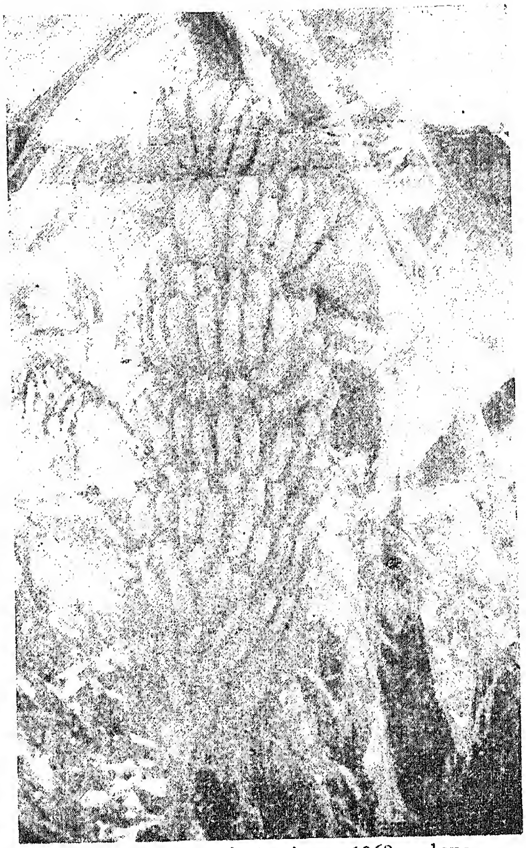
Date Palm windbreak



Windbreak of Pigeon Pea. Note asbestos irrigation pipe in the foreground



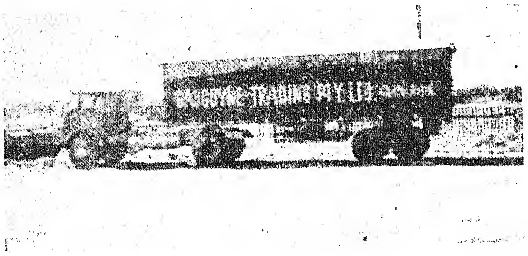
Record bunch on scales. Standard banana case for comparison



Record bunch—just prior to 1960 cyclone

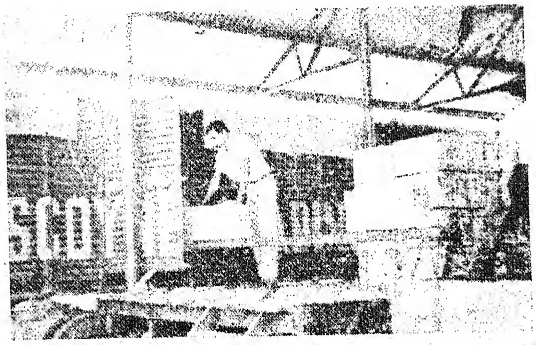
Record banana patch—just prior to 1960 cyclone

Bunches harvested from record patch



Transport specially adapted for banana haulage

Loading bananas into specially designed overland→ freighter. Such modern transportation has allowed Carnarvon growers to compete more than favourably with the New South Wales planters



In recent years many growers have changed over to fibrolite piping, for although this is more expensive than cement drains, it is easily transportable and can be shifted from one site to another. After several years of use, even the beat of cement drains develop cracks, and require constant attention. After six to eight years the average cement drain is ready for renewal.

On some properties large irrigation tanks have been erected, some of them up to 150,000 gallons in capacity. The purpose of these is to increase the efficiency of water usage during the dry period, for when only a small flow can be pumped it is used far more effectively if a big head of pressure can be built up before the final stage of irrigation takes place. If a trickle of water is pumped into bays or furrows, the time taken for the completion of the watering of large areas is far greater than it would be were a large flow used. This means that far more water is lost through seepage into the soil at the end nearest the outlet.

Many inefficient pumping units can still be found in the area. The level of the pump should be as close as possible to the level of the water, since as the suction head increases, the efficiency of the pump drops off extremely, and small defects in joints, packing glands, etc., very rapidly show up. On the delivery side, as few bends as possible should be used. Growers should remember that in a 3 in. line, a right angle bend in itself is equivalent to 7 in. of pressure head.

Some properties, due to their undulating nature, do not lend themselves easily to simple irrigation layouts. However, where possible, the grower should attempt to use a series of centralised channels to simplify his irrigation system.

Although earth channels have been condemned for years by Agricultural Department representatives and growers alike, many still exist. These can cost thousands of gallons of water in wastage each irrigation.

Channels should be arranged so that bays or furrows are moderately short. If practical, no bay or furrow should be longer than two chains. Beyond that length, wastage through seepage at the outlet end becomes an important factor, particularly as banana trash builds up.

The packing shed is a very important feature of each plantation. If possible, it should be handily placed from the point of view both of access to the crops and access to the carrier. Wet weather still causes much inconvenience to both grower and carrier where packing sheds are badly placed. The nature of the shed itself is important, particularly with respect to the care of bananas after harvesting. Many sheds in the Gascoyne are entirely iron or asbestos built, with very little ventilation, so that on hot days they actually raise the pulp temperature of the cut fruit, thus enhancing its chance of breakdown on the journey to Perth or in the ripening rooms. An excellent scheme is the inclusion of spinifex, straw, rush or trash walls, through which air can pass, and which on extremely hot days can be sprinkled from slotted piping, so that the temperature can be decreased. In some sheds of this nature a drop of 20 degrees on very hot days is not unusual.

Plenty of bench space is necessary in a packing shed, so that fruit does not have to be stacked too high on heavy packing days. Sufficient room should be allowed for the packed cases to be stacked well out of reach of the sun and within easy reach of the carrier.

Water

As mentioned earlier, Carnarvon is situated in a semi-arid zone of relatively low rainfall. In some pears rainfall can be completely discounted so that the success or failure of a plantation is dependent entirely on the quantity and quality of the water available for irrigation.

Most of the earlier settlers, their properties fronting the river, depended entirely on the water contained in the surface sands. This water has always been referred to as "top water," and its quality is usually very good. It is replenished completely whenever the river flows. However, there have been occasions in the past when, for up to four seasons, no river has flowed. The early settlers soon realised that in most parts of the river, top water alone was insufficient to see them through a long drought. Some bored through the first layer of clay beneath the

top sands and struck lenses of sand below, many of which contained good supplies of excellent quality water. Also though, a salt bore would be encountered periodically.

For a time the area was favoured with good prices as well as with good and reliable water. At this stage, very few were involved in the industry; in fact, up till 1949 less than 50 were actively engaged in banana growing. The early 1950's brought a boom in land sales and a corresponding increase in land values. Bigger areas were opened by the Government for selection, and some of the larger freehold blocks were subdivided. As a result of this, in the present year 138 plantations are functioning, and of these 117 are growing bananas full time.

All this means a corresponding increase in the draw-off of water, both from the temporary top water system and the static "second water." These second waters are referred to by the engineers as "static" due to the fact that they are not completely replaced with each river flow. It seems that they were formed thousands of years ago as the river channels changed course. In each change of course a virtual pool of sand would be left, and this would be slowly covered by consecutive layers of clay and silt from following floods. With the advance of time, it can easily be seen how successive layers of sand and clay have been formed beneath the delta area. It can also be understood, then, why the salinity of these second waters varies so greatly, not only in the quantity of salt contained therein, but in the chemical constitution of the salts themselves. Some, for instance, contain large quantities of gypsum (calcium sulphate); others magnesium sulphate, or perhaps even bicarbonates, which can be extremely injurious to crops.

It can also be seen why these lenses are not easily replenished by each running of the river, in fact, engineers have now established that within recent years the quantities of water contained in these have been steadily depleted, despite regular river flows, so that in 1959, the general second water levels were far lower than ever before, only nine months after the 1958 river had ceased flowing, despite the fact that most planters had carried on relatively easily during the 1951 drought.

Thus it can be seen that not only is water conservation and care in water usage essential, but also if the district's future is to be assured, some action on the part of the Government will be necessary to supply good quality waters to existing blocks. At the time of writing, a scheme has already been proposed, involving the utilisation of the large quantities of water contained in the sands beyond the Gascoyne River Bridges. Engineers have located deep, well-filled supplies here, and hope to pump from these through pipe lines to all points on both river banks.

Some growers have criticised this scheme. since they believe that these waters actually continue to flow down the river bed to replenish their own supplies. This is not the case. All of these waters are contained in basins and are static once river flow has ceased. It is hoped that they will be sufficient to adequately supply the area until a dam or dams are constructed.

Restrictions have been imposed by the Minister for Works, by means of which it is hoped to reduce the draw-off from the present systems and so carry on all properties for longer periods without stress in times of drought.

Shortage of water penalises the grower in two ways. Firstly, if the river is extremely low, as pointed out earlier the pumping unit will not be able to operate to its maximum efficiency, since it will be working against an increased suction and pressure head. This means that more and more fuel is necessary to pump the required quantity of water. Also, the grower's time must be taken into account. In times of shortage the affected growers must spend a great deal of time working on their wells and pumping equipment, or perhaps even in search for further supplies.

The danger of rising salinity is a very real one. Water containing 60 grains of common-salt (sodium chloride) per gallon is considered marginal both for bananas and beans. Some waters, in fact, although they are far lower than this in the salt content, may contain other salts such as bicarbonates, which will also prove injurious to plants. The danger of salt accumulations in the soil also becomes

evident. It is often impossible to avoid increasing salinity when one is pumping from a block bore or second water, but it is suggested that it is far better to maintain a light draw from a number of points rather than pump large quantities from one point. As the lens subjected to heavy draw-off is depleted, the increasing influence of saline seepages can be expected very rapidly.

Irrigation

The normal means of banana irrigation in the Carnarvon district is by flooding. After levelling the area, a series of "bays" varying in width from 8 to 18 ft. are formed by the throwing up of banks. This is carried out with a mould-board plough or "ditcher," (two opposed discs; see illustration). An opening from the cement channel is made into each bay, with a cement spoon-drain to prevent water erosion of the adjacent soil.

It is recommended that a fall of 1 inch per chain be incorporated into these bays, so that even after trash accumulation has occurred, irrigation can still be carried out easily. As pointed out earlier, excessive bay lengths brings about inefficiency of water usage; therefore, the recommended (optimum) length is two chains.

In the earlier years of banana growing in Carnarvon it was customary to plant into a series of furrows, which were later opened out into bays as the plants advanced in growth. This method was highly efficient in its water economy although it involved considerable work in the "opening out."

At the present time, banana irrigation practices are as follows: On heavy soils, such as those found in the south bank area, the crop is watered by the average planter at least once every week in summer (to a depth of 4 in. in the bay) and once every 10 to 14 days in winter, dependent on rainfall.

On the light soils of the north bank where far more rapid drainage occurs, twice weekly watering in summer is standard practice, and weekly watering in winter if the season is rainless and dry.

Although not always practicable, irrigation is most effective when carried out during the night, to reduce the evaporation percentage.

A water usage trial was conducted at the Gascoyne Research Station, and in the course of this, depths and frequencies of application were investigated. One section was watered to a depth of 4 in. at each irrigation, but was divided into three series of bays, one receiving this 4 in. twice per week in summer and once per week in winter, the second once per week in summer and once every 10 days in winter, and the third once every 10 days in summer and once every three weeks in winter.

In another section water was applied only at 1 in. depths with each irrigation. (This was done with a large number of outlet pipes through the centres of the bays.) Again this was divided into three parts, the first receiving four applications a week, the second three, and the third two—this being the summer schedule; the winter schedule was half this quantity.

The last section received water at varying depths—6 in., 4 in. and 2 in. Broadly, the result of the trial was as follows: It was found that the 4 in. application was equally advantageous as the 6 in. application, but with 2 in. applied with each irrigation the stand was somewhat poorer. Where 4 in. was applied every week in summer, the bananas were equally as good as those in the area receiving 4 in. twice a week. It was noticed that although the 10 day section was somewhat slower to reach the "canopy" stage, once this had been reached the harvesting results were actually better than from any other section in the entire trial. Five bunches over 100 lb. in weight were harvested from these three rows alone. In the section receiving 1 in. applications, it was found that after canopy formation, two 1 in. applications per week in summer were equally as good as four 1 in. applications.

After the conclusion of the trial, the water situation in parts of the plantation area became very drastic in 1959, and many growers were forced by circumstances to reduce their frequencies of application. They found that even where waterings were spaced out to once every fortnight in summer, if the bananas were at the canopy stage they continued to

produce as well as previously.

Thus it can be seen that if water economy is studied by the planter, his pumping costs per acre will be substantially reduced, and if only a limited quantity of water is available a considerable area of bananas could still be maintained.

A trial is now in progress on a private property on the light soils of the north bank of the river, and in this a number of methods of irrigation and frequencies of application are being investigated.

The quality of irrigation water is extremely important. It is considered by this Department that a water containing over 60 grains of common-salt per gallon is an extremely risky proposition for banana growing. Where a water has become saline (perhaps during a drought) and no other supply can be located, the depth of application should be increased and the frequency reduced. This method has been put into practice in previous years and found to be quite effective for carrying the plants on until better water is available. In the bay system of irrigation, very little salt accumulation occurs at the soil surface, but the average planter will notice some powdery accumulations occurring on the banks.

Planting

When planting the grower must first decide which spacing system he intends to use. There are two orthodox spacings, and each has it purpose.

The original "wide planting" system entails the planting of propagation material at 10 ft. centres—that is, bays are made up with banks 10 ft. apart, and the planting holes are dug 10 ft. apart in the bays. As the original parent plant becomes mature and suckers form around its base, three are left when gouging is carried out. These three then constitute the base number of pseudo stems on the area. It will be found that for the initial planting, 435 planting pieces per acre will be necessary, and after the first year, 1,305 stems will be the base number per acre.

The "close planting" system was designed by Mr. W. D. Marr, Tropical Adviser, 1949-53 and at the present moment a little over 50 per cent. of Carnarvon's regular banana growers have adopted it. Under this system, bays are formed with the banks 12 ft. apart, and the plants arranged on a zigzag pattern 5 ft. apart inside the bays, with a distance of 7 ft. across the bank to the next row of plants. (See illustration.) One sucker only is left on each parent plant. Here the base number of stems per acre is 1,355, thus it can be seen that if the measurements are closely adhered to, there is very little difference in the light intensity between the fully-developed wide planted patch and the close-planted patch in which the one-sucker system has been followed.

The advantages of the wide planting system are as follows:

(1) A much smaller quantity of planting material is necessary and hence the total amount of labour involved is far less.

(2) Due to the higher light intensity in the earlier stages, the suckers develop very rapidly indeed, so that little, if any, time lag can be noticed in harvesting. That is, before all the parent bunches have been cut, the following bunches are already maturing.

(3) If the "trench" system is followed at planting, water usage in the earlier stages is reduced.

Disadvantages:

(1) Only 435 bunches can be harvested initially, and due to the greater exposure of the plants and the bunches, the initial bunch weight is not usually high.

(2) A large area of bay is being watered for a small number of parent bunches in the first year if the bay system is adopted from the outset.

(3) Since the plants take quite some time to form a canopy under this system, weed growth persists for far longer, making for greater labour involved.

The advantages of the close planting system are:

(1) A large number of bunches are harvested per unit of area from the initial planting, and since these have been protected by the

closeness of the stems, the quality and weight are usually good.

(2) A far greater weight of fruit is harvested for the initial quantities of water applied, since it takes just as much water to produce 435 bunches under the wide planting system as it does to produce 1,355 under the close.

(3) Weeds are completely eliminated after approximately six months of active growth, since the canopy stage is reached quite early.

Disadvantages:

(1) A bad time lag occurs between the harvesting of the parent bunches and the harvesting of the first of the follower bunches. This is due to the fact that at an early stage the light intensity inside the patch is reduced, and with it the rate of sucker growth is decreased.

(2) Since the original parent crop is so even in its rates of growth (so that most of the bunches are thrown at once) a "burst" of production often occurs, and this can be a disadvantage from the economic viewpoint.

(3) Once again due to the even rate of growth, it will be found that the canopy formed by the parent plants reduces the light intensity far more than the canopy produced by the followers, since the rates of growth of the latter are much less even (first followers may be noticed in all stages of height and girth). Sometimes due to this low light intensity in the parent, close planted crop bunches fail to "fill" as they would if the light intensity were higher.

The major differences obviously only occur in the first two years of growth. Thereafter, the two methods are extremely similar. Each, of course, has its purposes. If a grower wishes to have as large a sum of money as possible come in quickly from his banana crop, the close planting system offers the best avenue. If, however, he has the time to come somewhat more slowly into production which is more regularly spaced over the first few years, he follows the orthodox wide planting system.

On certain sections of the river (particularly where light soils are encountered) patches often fail to carry on beyond the "first follower" bunch. (The probable reasons for this will be discussed later). Where this occurs, the close planting system is the only one which can be even considered.

Apart from these two orthodox systems, many other variations have been practised. Many growers have planted in rows 9 ft. apart with a distance of 7 ft. between the plants and 8 ft.$\times$8 ft. on a square leaving three followers on each. After the parent crop, these are far too close, and sucker growth is reduced. Also, bunches fail to fill as they should, and fruit quality becomes poorer, due to the lack of light intensity. One particular grower has in recent years parctised a 9 ft.$\times$7 ft. planting, leaving only one follower on each parent. As a result, the bunch size of each following crop was far greater than in most other patches in the area, and the individual fruit quality has yet to be bettered. Perhaps the only disadvantage is the excessive size of the individual fruit. It was found that sucker growth was extremely rapid, so that bunches were produced within a shorter time than in the orthodox systems. Although fewer bunches are harvested from the parents than in the close planting system, a patch such as this will rapidly "catch up" on the first and second follower crops.

Some people have attempted to bring bananas even closer than the orthodox 5 ft.$\times$5 ft.$\times$7 ft. (close planting). Admittedly more bunches are obtained per acre, but sucker growth is so drastically reduced that no reduction in spacing can be advocated.

Having decided which system he intends to use, and having applied a preliminary watering, the grower then digs the planting holes, either by shovel or mechanical post-hole digger tractor (a tractor attachment). These are sufficiently deep to allow for the planting material to be set into the ground to a depth of 15 in. to 20 in. Where the post-hole digger is used, particularly in soil which has a relatively high clay fraction, the grower should be sure to "break in" the sides of the hole before

planting the banana, since through the action of the digger these sides are inclined to set so hard that often the soft banana roots have considerable difficulty in passing through them.

In past years it was common practice to put a small quantity of fertiliser into each hole, but this is no longer considered necessary by this Department.

Types of planting material vary widely, and each type has its particular advantages. Maiden butts or suckers are usually well suited to spring and early summer, or very late summer plantings. (A maiden butt is a very advanced sucker which has not, at the time of digging away from the original stem, produced a bunch). Butts, and pieces of butts with "eyes," or small suckers are best used throughout the hotter months of the planting season, as they are less inclined to rot.

Actually, when planting material is scarce, growers have been obliged to use material of all kinds, some of which, years ago, would have been considered as being of very poor quality. It must be remembered, however, that genetically, all planting material is exactly the same, since the domestic banana species are reproduced by vegetative means only. This has been proven in recent years, as a result of the close planting system being used on such a wide scale. Old and so-called "run-out" suckers, old sections of butts from pseudo stems which have produced, and even what could almost be termed "water suckers" have been used in some of the larger patches, and yet at the time of harvesting no difference can be discerned, except where very advanced maiden butts have been planted. Here the bunches, although being produced far earlier, are usually much smaller due to the reduction in leaf area prior to the formation of the embryo bunch within the base of the pseudo stem.

It has always been considered a poor practice to use suckers from a one-year old, or younger, plantation, as these are very inclined to rot (or "boil") in hot weather.

It is wise to dip all material to eliminate nematodes before planting. This will be discussed separately in a later section.

Planting material is obtained from old patches which have been or are being abandoned. It is normal practice to give the patch one irrigation to soften the soil just prior to removal of the material, then where possible a small hole is dug at the base of each pseudo stem on the side remote from the position of the old underground stem. The desuckering bar is then used to separate the standing stem from the old butt, and with leverage it is toppled in the direction of the hole. The purpose of the hole is to make this toppling easy and prevent damage to any small suckers which may be present. Suckers, if sufficiently advanced, may then be removed from the stem, and the butt may be cut off and if necessary, hacked into sections, each with an "eye" or small sucker. Cut surfaces should be allowed to dry (or cork) a little before planting.

Where suckers or maiden butts are used, the top of the stem is cut through so that all leaves are removed. This reduces the transpiration rate. On all planting material, all roots "barbered" away; in fact, it has been found recently that sometimes even the outer "skins" of the butt or sucker can be peeled off almost like a potato skin. This reduces nematode infestation.

On the heavy soils of the south bank (and of the gullies on the north bank) it is advisable, after covering in the planting material, not to apply any irrigation water for several weeks. It will be found that moisture retained in these soils will be sufficient to encourage new roots to develop, and produce growth in whatever material happened to be used. If water is applied too soon, and hot days are encountered shortly afterwards (which is always a possibility) many misses will occur through "boiling." On the lighter soils, which dry out far more quickly, one watering can be applied immediately after planting, and then the patch can be left for a fortnight before further irrigations are made.

Banana planting is normally carried out from August to March inclusive, and as with planting material and spacing, there are advantages and disadvantages to the various planting times.

Early planting (August to December) usually gives an excellent "strike"; the plants are well advanced before the onset

of winter, and thus better able to withstand the cold. However, bunches from such plantings are normally harvested when fruit is very plentiful—that is, in the poorest marketing period, and it is found that the peak of production continues to coincide with this time.

Later planting usually brings peak harvesting into the winter shortage period, the advantages of which are obvious. However, planting in the hotter months often becomes a gamble, since many misses can occur. Also, the plants are still very small at the onset of winter which means that they are more susceptible to cold weather damage and severe weed infestation.

Replacements are sometimes necessary if many of the planting pieces fail to "strike," and these should be planted at a very early stage if possible; otherwise they have little chance of producing if the remainder of the patch has decreased the light intensity of the environment.

Cover cropping trials have been carried out on private plantations with no beneficial results. Cover cropping amongst young bananas has been found less desirable than keeping bays clean of all growth other than the bananas themselves. However the intercropping of late season banana plantings with runner beans is recommended as a valuable practice. Added protection from wind and cold is afforded the young plants, and growth rate is increased.

Varieties

In the Gascoyne area, only Cavendish bananas are planted. These are (1) the original Dwarf plant locally known as "Cavendish," and (2) a mutant from this, the Williams Hybrid or Golden Gros. The former have lost popularity in the Carnarvon district, despite the fact that the majority of them remain standing even after cyclones of high intensity. Their waning popularity is due to, firstly, the difficulty found in working amongst them —(the throats are often no higher than 5 ft.); secondly, they are extremely prone to cigar end rot and other secondary fruit damage brought about by the more compact nature of the arrangement of the hands which imprisons the bracts, preventing them from falling clear. Lastly, they have a much greater tendency to "choke" when adverse growing conditions are encountered. This often means that as much loss can result after a cyclone in a "Cavendish" patch, even though it remains standing, as in a patch of Golden Gros which has been almost entirely flattened. They are most intolerant to cold conditions, and very often over 50 per cent of the plants will choke as a result of a cold winter.

It is worthy of note that in Queensland and Northern New South Wales a similar trend is taking place.

Wind Breaks

As mentioned earlier the district is subject to extremely strong winds in summer. As a result of these strong winds, either the outer two or three rows of bananas on the southern aspect of the patch must suffer heavily from their effect, or a suitable windbreak should be grown or erected to minimise the effect of these winds.

Many tree species have been tried by growers as permanent windbreaks. To name a few of these in order of importance, Athel Tamarisk, River Gum, Mangoes, Dates, and Tecomas. Other live windbreaks of a more temporary nature have been used in recent years are Plantains, Bamboos and Pidgeon Pea.

A number of windbreaks have been tested at the Research Station, so that recommendations could be eventually standardised. Tamarisks, gum trees, tecomas, macadamia nuts, thevetias, pidgeon pea and sugar bananas have all been tested. Several obvious disadvantages have been noticed in the tamarisk and gum tree breaks. Firstly, when in close proximity to the banana patch these have a tendency to cause very strong winds to eddy on the lee side during cyclones, and this effect is just as disastrous to a stand of bananas as a direct blast. Also, it was found that the tamarisks under certain conditions will rapidly accumulate salt in the leaves, and this salt is later spread around the surface of the soil in the near vicinity of the tree as dead leaves fall, and rain drops or heavy dew cause the leaves to drip.

Two other drawbacks to the tall-tree windbreaks which may cause damage to

plantations are (1) the excessive shade produced, and (2) the enormous root spread throughout the damp banana patch. Tamarisk roots have been ploughed up 150 ft. from the nearest windbreak on occasions.

Plantain and lady finger banana windbreaks are, unfortunately, not regularly attended by growers, so that ripening bunches may often be found on them. Needless to say, this promotes an increase in fruit fly numbers. These plants also are susceptible to Panama disease, one of the most serious diseases of bananas in other countries. For these reasons windbreaks of this type are no longer recommended.

The Yellow Tecoma (*Tecoma smithii*) is considered an excellent windbreak for three reasons: firstly, it grows rapidly to its maximum height; secondly, it does not grow into a tall tree but remains at approximately the same height as the banana crop, and thirdly, it has to date shown no tendency to compete in any way with the bananas. It forms quite dense foliage, and in spring produces most attractive yellow bell-shaped flowers. It is easily grown from seed.

Pidgen Peas are also most useful but, unfortunately, do not last much longer than two years. Little trial has been given on private plantations up to the present time to permanent windbreaks such as dates, macadamias, olives, etc., but all of these have possibilities. Bamboos and artificial windbreaks built of gidgee poles, wires and trash (which is later overgrown with a creeper) were used extensively some years ago, but are now rarely found since, in the case of the former, it is found that the bamboos compete too heavily with the crop, and that the latter rapidly become unkempt and difficult to maintain. They also harbour vermin.

Nematodes

Recent investigations have shown that in the Carnarvon area, nematodes or eelworms seriously limit the production of bananas and are probably the most important pest of this crop.

Damage from this pest was first suspected some years ago when it became obvious that banana patches, particularly on the lighter soil types, were prematurely "fading out" after the production of the maiden bunch; and when an increasing number of abject failures resulted from replanting on old banana ground.

Plant pathological examination showed that banana roots grown under these conditions were heavily infested with nematodes of several different species. Some species, *e.g.*, root knot, cause obvious root galls or swelling, while others, *e.g.*, *Radopholus*, rot the roots and penetrate the underground stem giving rise to the condition known locally as black rot.

When the first control trials were initiated, fumigant materials were limited to D-D and E.D.B. compounds which had to be applied at least three weeks before planting by drip feeding into the plough furrow. It was also necessary to disinfect the planting material, and organic phosphate insecticide were used for this purpose.

In 1958 the Government Plant Pathologist obtained test quantities of a new water miscible fumigant composed of 1, 2 dibromo 3 chloropropane. A number of "spot trials" were commenced at Carnarvon on private plantations which had been previously affected by nematodes. After six months it was obvious that great benefit had been obtained, improvements being noticeable in several respects. The treated stools continued to produce healthy suckers which, in turn, produced healthy plants, instead of falling away drastically in vigour during the winter and then falling completely. The bunches produced from these following suckers were often even better than those of the parents. Thirdly, the new suckers themselves, when dug up, were found to have clean white root systems with abundant fibre root, and clean healthy butts completely devoid of any black rot.

This water miscible fumigant is now advocated by the department for regular use by planters. It should be applied during the warm months of the year (the first application preferably in spring) and the treatment repeated at least every 12 months. Its application is extremely simple. On young patches (up to two years old) a rate of one gallon per acre is normally advocated; for older patches,

the two-gallon rate is recommended, After the quantity to be applied to each bay has been worked out on a per-acre basis, the fumigant is bulked up with water in an open top four-gallon tin, into which a petrol tap has been soldered. This tin is set up over the cement channel and the rate of flow of fumigant from the petrol tap is regulated as closely as possible so that the tin is emptied as the bay is completely filled. This means that the fumigant has been evenly dispersed throughout the entire flooded surface, and can penetrate to all the plant roots.

Just prior to the disastrous cyclone in March Carnarvon's banana crop was looking its best ever, partly due to the widespread application of this fumigant. Since the cyclone, most of the patches which were previously treated are now making excellent recovery. It is relieved that, with regular eelworm control practised on the plantation, the productivity per acre should rise by at least 25 per cent., and the life of the plantation will be extended very considerably.

Weeding

To get the maximum first bunch production from a banana patch it should be kept free from weeds from the outset. Most weeds can compete far too vigorously with the soft and flabby-rooted bananas, and if allowed to run riot will retard them so badly that often they need to be replanted.

The easiest way to control weeds is to prevent them from ever reaching any size. Normally, chipping hoes are used to keep weeds down, although in wide planted patches the use of rotary hoes is also possible. (The use of the latter is not advised in summer, when the roots of the plants have come up almost to the soil surface, but in winter, when a semidormancy occurs, its use is often beneficial.)

In the Eastern States, weed control with arsenical weedicides is often practised, but this is not advocated for Carnarvon conditions due to the possible residual effects on following crops. The use of some of the newer weedicides is being investigated but it is still believed that to obtain the best results from the plants, regular control with the hoe until canopy formation, is still the most effective. After canopy formation, weeds no longer survive, due to the excessive shade.

Fertilisers

For many years it has been believed by growers that since the banana plant is large and its growth is rapid, it must require large quantities of fertiliser, and this is reasonable to assume. No standard practice has been advocated, but most growers have usually applied one or more of the animal fertilisers such as blood and bone, whale meal, whale solubles, and some of the inorganics (super, sulphate of ammonia and sulphate of potash.)

The rates and times of application have varied from plantation to plantation, but one point has always been obvious: fertilisers have been one of the main items of expenditure on plantations. They would certainly constitute one of the major cost of production per acre.

A trial was initiated at Gascoyne Research Station in 1952, to investigate the main fertiliser constituents necessary for banana growth. Nitrogen, phosphate, and potash were applied to test rows singly and in their various combinations. Buffer rows and control rows were also incorporated. Up to the time that the patch was destroyed by the March cyclone, no difference in bunch weights had been recorded. That is, over the entire period, no benefit at all had been obtained from the use of fertiliser of any kind. In the last year of life of the patch, however, it was noticed that rows receiving nitrogen and potash together were slightly greener and the plants had a slightly greater girth measurement than those in the remainder of the patch. This was not transmitted to fruit weights.

These results seem extraordinary, and in fact are disbelieved by some banana growers. However, when the banana analyses are studied the seasons become a little more obvious. Principally, banana plants contain water and cellulose. There is relatively little nitrogen and practically no phosphate in any part (including fruit), and although eight times as much potash as nitrogen is present, this figure on a weight-per-acre basis is still extremely low.

Assessing just how much of each ferti-

liser constituent will leave the banana patch each year, fruit analyses must be considered. Typical analyses of Carnarvon fruit are as follows:—

Samples:	1		2		3		4	
	Skin	Flesh	Skin	Flesh	Skin	Flesh	Skin	Flesh
Weight (grams) ...	400	632	397	708	338	637	389	651
Moisture % ...	90.8	75.4	89.7	76.6	90.7	78.0	90.7	76.3
Reducing Sugars % (as dextrose)	1.9	14.9	2.3	17.0	1.7	16.4	1.8	15.8
Starch % ...	1.0	7.9	0.4	6.3	0.4	7.2	0.9	8.4
				Parts per million				
Nitrogen, N ...	1110	nil	1140	nil	1340	nil	1100	7
Potassium, K ...	8300	4400	8500	4250	9200	4100	8100	4150
Calcium, Ca ...	393	75	452	89	325	56	348	70
Magnesium, Mg ...	149	435	178	419	132	379	141	425
Phosphate, P ...	303	240	324	270	291	219	280	263

The would represent 100 lb. of sulphate of ammonia, 500 lb. of sulphate of potash and 50 lb. of super, which must actually be replaced each year; a very small quantity by comparison with that normally applied by the average planter.

Recently a small number of planters had their fertiliser programmes on this basis, and experimentally applied little or none from the outset. To date no difference can be seen between plants receiving fertiliser and those which have been completely untreated.

A good healthy root system and good quality water are the two most important factors in banana production.

A number of well-mixed balanced concentrated fertilisers are now available, and a light dressing of such as these once or twice per year is advocated as a precautionary measure to cover replacement in the soil. Fortunately, Carnarvon's soils are inherently very fertile.

In some cases excellent response has been obtained to the application of sheep manure at extremely heavy rates. This is most probably due to the effect on the soil's structure, since weathered sheep manure actually contains very little of manurial benefit.

The effect of the various fertiliser constituents on fruit quality has been thoroughly investigated at the research station, and also in Perth with the cooperation of the Research Branch. No concrete results were obtained, since any variations were only slight.

During hot weather, though, there were indications that excesses of nitrogen fertiliser are deleterious, and can induce premature breakdown.

Desuckering

As the plant advances in growth, suckers are formed around its base in the manner typical of all plants of this order. Surplus suckers must be removed so that the light intensity in the patch will not be excessively lowered, and so that individual stems will remain vigorous and produce large bunches. It is false economy to leave too many "followers" in a patch, as bunch size and rates of sucker growth are practically diminished.

As mentioned previously, under the wide planting system three suckers are left on the original parent stem in the first year. Thereafter, one sucker only is left on each stem. Under the close planting system, one sucker per stem is left from the outset.

Under Gascoyne conditions, desuckering is normally carried out with a gouge. A simple but effective gouge is easily made from the main leaf of a car spring. Thsi

is straightened and cut to a length of approximately three feet leaving the shackle loop on one end to serve as an aperture for the handle. The cut end is then drawn to a point and made slightly concave. (See illustration). A short piece of wood passed through the shackle loop serves as a handle. This implement is used by thrusting the point down between the sucker and the main stem, then rotating the handle so that a cone-like cut is made into the heart of the sucker. By this means it is completely detached, and can be pulled out and discarded.

When selecting the sucker or suckers to be left on the parent plant, it is wise to take into account positioning as well as size and vigour of the suckers themselves. If the wide planting system is being used, three suckers should be left as nearly equidistant from each other as possible. In the close planting system, an attempt should be made to keep all the suckers "heading in the same direction," this always being along the rows, not towards the bank or the centre of the bay. Sometimes this is not possible but it should be accepted as a general rule.

Concerning individual suckers themselves, those selected to be left on the parent should not be too close to the butt, since as they grow they will be constricted for room. The closeness of the parent also usually indicates that the sucker has come from a shallow depth, which is undesirable. Ill-shaped or off-type suckers such as so-called "water shoots" should be removed in any case.

Several other systems of desuckering are now being used on the Gascoyne. Some growers constantly keep unwanted suckers cut back to ground level, while others crush those which are newly emerging with the heel. Neither of these methods are recommended, as they are not sufficiently permanent. Due to its simplicity and speed of working, desuckering with a petroleum product is being used quite extensively. The unwanted sucker is cut off almost at ground level, and a small recess is made into the top with the point of the knife. A teaspoonful of kerosene, petrol or distillate is then squirted in with an oil-can or tipped in from a bottle. Some growers claim big successes with this method, whilst others have abandoned it and gone back to the gouge because they have found that too many survive the treatment.

Trashing

As each individual pseudo stem progresses towards maturity and bunch production, the older outermost leaves die back. These are removed for two reasons: firstly, when hanging in quantity they can reduce the light intensity around the base of the plant and retard sucker production and growth, and secondly, the dead leaves can often damage young fruit between flowering and the time the fruit is harvested. Wind movement in the patch is often responsible for the scaping of a dead leaf over several hands of fruit, causing severe blemishing.

Trashing is the removal of these dead leaves by cutting off back to the live portion of the leaf sheath. Sometimes the entire sheath is dead, in which case it is cut off at the base of the pseudo stem. As they are removed, these leaves are usually heaped into the centre of the bay, where they progressively rot away with the constant watering and the action of fungi and bacteria. Usually, many earthworms may be found amongst the rotting trash, and in summer, if the bananas are in healthy conditions, many of the young roots may also be found there in a large quantity. When trashing it is wise to keep dead leaves and stems away from at least one of the banks so that water flow is not impeded during irrigation. Drastic water wastage results from a big build-up of trash through which no channel has been left.

Bunch Covering

In northern New South Wales banana growing districts, it is considered good policy during winter to cover maturing bunches with plastic "aprons." This sometimes results in a 10 per cent. increase in bunch weight, and far less bunch marking and damage. Trials were carried out by the Department of Agriculture at Carnarvon, and increases in weight of up to 5 per cent. were obtained under winter conditions, but due to the cost of the plastic bags at the time, it was extremely doubtful if covering was justified economically. It

is noteworthy that fruit which had been covered was far cleaner and had much better "bloom" than that from control rows.

Pests and Diseases

Namatodes have to-date been Carnarvon's most important economic pests, and these have been dealt with in an earlier section.

This Gascoyne settlement is well removed from other commercial banana growing areas. From the inception of the industry at Carnarvon strict quarantine measures have been adopted to minimise the chances of infestation by the many diseases which can affect the crop.

So far these have been very effective and the district has remained largely free from serious disease problems.

Harvesting

It is very difficult to lay down any well defined rules for judging the maturity of the bunch which is ready for harvesting. Each planter will finally be able to judge, from constant experience, just how long his fruit will "hang" without becoming too full and prone to ripening in transit or breakdown. There are several good guides which could be useful to the inexperienced grower, however. The first is the appearance of the leaves of the plant. If very few healthy leaves remain on the pseudo stem, the bunch will rarely fill to any greater extent than it already has done. Secondly, if the "tassel" (which consists of a mass of bracts enclosing the male florets) has died off, the bunch is usually ready to be cut, and thirdly, when the stigma (the last remaining portion of the female floret at the end of the banana itself) has completely dried off and shows no tendency to bleed when broken off, this also is considered a guide to maturity. The appearance of the fruit will finally be the main criterion upon which the planter will judge his harvesting and, as pointed out earlier, the development of this judgment will come with experience.

It is considered that to allow fruit to fill to its absolute maximum in the hot months of the year is unwise, as it leaves fruit very prone to premature breakdown after ripening. This is one factor which is blamed for the poor quality claims made against Carnarvon fruit in the Perth shops and markets. It must be remembered that New South Wales fruit being sent to W.A. is cut at the "full three-quarter" stage.

An article on fruit quality, packing and waxing appeared in the January, 1960, issue of this Journal.

Bunches are usually cut with a long-bladed knife, and then the entire pseudo stem is also cut back and thrown amongst the trash. Some growers then chop it into short lengths, which assists it to break down more rapidly. The cut bunch has stood carefully against the nearest bank. When the grower has been through the entire patch, he carries out the bunches to a waiting vehicle (truck, utility, trailer tractor and trailer, etc.)

Great care should then be exercised in the placing of the bunches on this vehicle. They are best transported "upside down," that is, with the tassel end uppermost, so that the bottom hands are not damaged. Where any bunch has to be leaned against the side of the vehicle, bags should be hung. Bunches should never be laid on their sides as extreme bruising will result. This may not be obvious while the fruit is being dehanded and packed, but will later show up after ripening on the market floor.

Yields and Duration of Plantings

As pointed out in an earlier section, Carnarvon's average banana yield per acre is higher than that in northern New South Wales or Queensland. In the truly tropical countries where most of the world's bananas are grown, yields are low by comparison with such areas as the Canary Islands and other countries where irrigation and more intensive cultivation is practised. In Central America and West Africa, for example, anything over 10 tons per acre per year (280 cases) is regarded as exceptionally good. In the Canaries, production has reached 19 tons (or 530 Carnarvon cases). But at Carnarvon, maximum yields have gone far higher than this. From a patch at Rokich Bros. plantation, over 1,000 cases per acre were produced in the nine months prior to the cyclone in March 1960. Two days after the cyclone, a bunch weighing 144 lb. was

taken from the wreckage.

Carnarvon's annual average per acre can certainly be lifted by means of regular soil fumigation, weed control, and more care per acre. If an individual grower can exceed 1,000 cases, the district average could surely be raised to 500.

In recent years, the productive life of each banana planting has been reduced by nematode infestation on most areas of the Gascoyne. However, some of the older growers who have been relatively unaffected by this pest, hold patches for 9 years up to the time of the cyclone. Over the next decade it is quite possible that retention of patches will be possible on most properties where fumigation is practised.

It is advocated that a small area of bananas be planted each season, so that in the event of a cyclone, the oldest section may be abandoned.

In some banana growing areas (*i.e.*, parts of India), patches up to 100 years of age are not uncommon. This is achieved by judicious sucker positioning, and the complete removal of rotting butts, which are sometimes replaced with soil.

Transport

All Carnarvon's primary products are transported to the Metropolitan Markets, in Perth, by the Gascoyne Trading Company, a subsidiary of Westralian Farmers' Co-operative. This Company operates a fleet of large, fast and modern diesel trucks, specially designed for the haulage of perishable produce under hot conditions. The metal sides of each body are fluted to allow the passage of air around bags and crates ; and the front panel is entirely lowered, once again for ventilation purposes.

The trucks reach Perth after only 22 hours of travel, and since most of the highway is now bituminised, delays are most infrequent.

The company also maintains a staff of mechanics to cope with repairs, regular servicing, and breakdowns. Over the last three years these transports have never missed a market, which is a tribute to the efficiency of the organisation.

Freight rates for the cartage of primary produce from Carnarvon to Perth are surprisingly low, bananas 11s. 6d. per case, beans 5s. 1d. per bag (approximately 1⅔d. per lb.).

The banana crates are carefully loaded and offloaded along rollers, and no "break" in the journey occurs (as was the case some years ago, when both road and rail were used, necessitating extra handling).

Several tests with cardboard cartons have been carried out, but to-date no carton has been satisfactory for banana transport. Firms manufacturing cartons, however, will quite probably produce a satisfactory container within the next few years, and this will further facilitate handling.

Prospects of the Industry

Although a very few years ago the prospects of the Carnarvon banana industry seemed anything but bright, in view of falling productivity, shorter duration of patches, and the severity of New South Wales competition, it now seems safe to predict that its best years lie ahead, for the following reasons :—

(1) The simple and effective control of eelworm through the application of water-miscible nematicides, giving the plant a clean root system each season, and increasing the productive life of a patch as well as its production per acre.

(2) The probability of increased supplies of irrgation water becoming available.

(3) The increase in efficiency of water usage by the average grower, reducing costs per acre (this is assisted by fumigation. which, in cleansing the root system allows more efficient water uptake by the plant from the soil).

(4) Through better packing, and waxing, a higher price for Carnarvon bananas can be maintained above that of the New South Wales article (which must be transported over greater distances).

(5) The opportunity to insure a banana crop in Carnarvon. Previously, no insurance company would take such a risk, but a scheme has now been formulated involving contribution by the Government and grower subscription by levy. This will give far greater security from impoverishment by cyclone.

(6) The constant improvement in the North-West highway, which will shortly be entirely bituminised. This will enhance the

ability of the transport company to operate at lower costs.

For these reasons, it is quite possible that within the next five years, Carnarvon's expanding banana production could completely satisfy the Perth market's requirements (which, with increasing population, would be 160,000 cases annually—compared with 86,000 from Carnarvon in the 12 months up to the time of the cyclone).

This Department has an Agricultural Adviser stationed permanently at Carnarvon, and growers are reminded that much expense and trouble may often be avoided by discussing their banana problems with him.

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BANANA, IN EAST PAKISTAN

INTRODUCTION

The banana has been known as one of the most familiar and attractive fruits of the tropical countries. It is regarded as a fruit of excellent quality and at places as a rare luxury. Banana stands first among all food crops of the world in the supply of calories produced per acre. Vitamins A, B, and C are found in reasonable amounts and D and E, in small amounts in banana. While different parts of the plant are worthfully used, various food products, such as banana figs, banana chips, banana alcohol, vinegar, jam, etc. may be prepared out of banana.

It can be grown in any part of East Pakistan. From data supplied by the Government of Pakistan in their Fact Series No. 2, "Crops, Vegetables and Fruits in Pakistan" we find that while the annual production of Mango in East Pakistan is 89 lakh maunds, Coconut 16 lakh maunds, and Pineapples 3 lakh maunds, banana is produced to the extent of about 3¾ crore maunds. It will be quite evident from these figures what an important place banana occupies in this Province from economic point of view.

AREAS OF PRODUCTION

It will be interesting to note that this fruit-par-excellence, though cultivated much extensively in the tropics of western hemisphere probably originated in parts of tropical Asia, such as, Indo-Pakistan and Malaya. From its original home somewhere here banana has spread all over the tropical world and today there is almost no warm region where it is not grown. The main banana growing areas of the world are Central America, West Indies, Brazil, India, Pakistan, South and East Africa, Ceylon, Malaya, Philippines and Australia. In East Pakistan the areas and production of banana in the different districts are roughly as follows :—

District	*Acreage Acres*	*Production Mds.*
Dacca	11,050	55,25,000
Mymensingh	8,800	44,00,000
Faridpur	5,500	27,50,000
Barisal	4,400	22,00,000
Chittagong	2,200	11,00,000
Noakhali	880	4,40,000
Tipperah	4,400	16,50,000
Chittagong Hill Tracts	1,100	5,50,000
Rajshahi	7,700	38,50,000
Rangpur	8,800	44,00,000
Dinajpur	5,500	27,50,000
Pabna	7,000	35,00,000
Bogra	4,400	22,00,000
Jessore	4,400	22,00,000
Khulna	7,700	38,50,000
Sylhet	Data not available.	

THE VARIETIES

A good number of varieties of banana is under cultivation in this province. Some of the commercial varieties are extensively grown in most areas while others are localized. Let us have a brief survey of the characters of the well-known ones :—

(1) *Safri.*—Safri, one of the two best dessert banana of East Pakistan, is grown in all parts of the province and is known as 'Malbhob' in Rangpur and Dinajpur and 'Anupan' in Rajshahi. The fruit is absolutely seedless. Finger is straight to curved and medium long. Pericarp is stratur-yellow ; pulp soft, malleable sweet and delicious.

(2) *Amritsagar.*—Amritsagar, one of the two best dessert bananas of East Pakistan is particularly met with in the Rampal areas of Munshiganj sub-division, Dacca. The Government of East Pakistan considers this to be the best variety from point of view of quality and production. The fruit is seedless, finger is oblong, falcate and long. Pericarp is lemon yellow; pulp sweet, scented, soft, melting and delicious.

(3) *Champa.*—Champa is grown quite extensively and a great majority of the areas under banana cultivation is covered by this dessert variety. The fruit is almost without any seed. The finger is somewhat short; pericarp is bright lemon yellow; pulp soft; malleable, sweet slightly aciduous.

(4) *Agniswar.*—Agniswar is grown to a limited extent. The name might have originated from the reddish pigmentation, of the pericarp. The fruit is seedless, finger is oblong, slightly curved and medium long; pericarp peach-red, sweet, with deep aroma which is not much agreeable, soft and melting pulp.

(5) *Dudshar.*—Except the colour of the pericarp which is greenish yellow, the size of the fruit, its taste and quality are almost identical to Agniswar. This is also very rarely grown.

(6) *Kabri.*—The Kabri, though an inferior table variety is commonly found in the homestead gardens and is popular amongst the poor. It has different names, such as Manua, Madhua, Jinkala, Thuta, Shail, Shamong, Bargle, Bhat etc. The fruit occasionally contains a few seeds, finger is oblong and almost straight, medium long, pericarp dull yellow, pulp sweet, aroma not so agreeable.

(7) *Singapuri.*—This is an introduced banana and is not largely cultivated in the province. This banana has been known under the names of Jahaji, Kabuli, and Nepal also. This is a superior dessert banana, seedless with finger oblong, falcate and long. The pericarp is green to greenish yellow. The pulp is sweet, with a negligible aroma. The bunch is very big.

(8) *Kachkala.*—There are a number of types of Kachkala, the name signifying banana used in unripe stage, as a vegetable. This is worthg givin to the patients after ailments owing to the easily digestible nature of the fruit. The fruits are stout and medium long to long. The pericarp is greenish yellow to light, yellow when ripe, pulp dull in sweetness, somewhat pasty and poor in table quality.

(9) *Aitakala.*—All the seeded bananas, such as Jhawa, Shangi, Botur, Bhim, Goma, Peti, etc., come under the group Aitakala. Fruits belonging to some of the varieties are exceedingly large in size, while others are medium, but almost all broad in diameter. The pericarp is light yellow to yellow with coppery specks in most varieties. The fruits are full of seeds, pulp sweet, but somewhat pasty.

SOIL AND CLIMATE

The plant thrives well in medium deep, fairly heavy and moist soil containing a good proportion of humus. The sandy loam or loam soil on the raised banks of tanks, canals, swamps, etc. Where there is no danger of water-logging but where the soil is enriched by the addition of silt obtained by digging up the bottoms of such water—reservoirs is supposed to be highly suitable for banana in the province. The most suitable climate is one with warm, moist weather throughout the year. Strong winds damage the crop badly.

PROPAGATION

The banana is propagated by vegetative means, that is, through suckers which arise from the bases of the parent plants. Suckers are of two types *viz.*, sword suckers and water suckers. The former ones with narrow but strong leaves, are superior to the latter ones with broad spreading leaves, Safri Champa, Kabri, Agniswar and Kachkala banana plants have been observed under Dacca Farm conditions to stool 5—10, 6—11, 7—9, 5—7 and 5—8 suckers respectively with Amritsagar variety giving out as nearly as 10—13 suckers and Singapuri giving as low as 3—4 suckers.

SELECTION OF SITE

Shady plots surrounded by tall trees are occasionally selected by many growers, owing to dearth of sufficient space or ignorance. But there are prudent growers too who select the site for banana on the banks of newly-dug-out ponds and canals. The

banana plants on this type of land flourish, blessed by the presence of sufficient nutrients in soil carried through silt, sufficient sunshine and proper drainage. The land should be fertile one, to be further enriched by the addition of manure and fertilizers. The improved varieties of banana which are not as hardy as the inferior ones to stand adverse circumstances of soil and environment demand special care in the selection of site for their planting.

TIME OF PLANTING

The usual time of planting observed by the growers throughout the major parts of the province is the advent of the rainy season, soon after the first one or two showers come down. There does not seem to be any harm in planting bananas during May—July in such plants where the soil is loam or sandy loam. But this time is not at all suitable for the Clay-soil of the places under Madhupur Tract which Dacca Farm also. Different planting trials have indicated the month of February and early part of March as the best planting time here for banana, specially for varieties like Amritsagar, Champa and Singapuri which fruit early. The planting during this time will, however, demand occasional profuse irrigation after planting till the start of the monsoon.

PREPARATION OF LAND

Most growers do not feel the necessity of preparing the land well having the impression that banana being a tree crop does not need any preparation of land at all except making small pits just sufficient to insert the bases of the suckers. But the root systems of banana have the special characteristics of being shallow and spreading through the under-surface of the soil to distant part covering the whole space kept in between the plants. Intelligent growers, therefore, prepare the land to the best possible manner and clear the land of all sorts of weeds.

LAY-OUT OF THE PLAN

A well considered plan is one of the most important prerequisites, for banana plantation. The square and hexagonal systems are the best ones to be followed in banana growing, preference being given for the latter. A judicious experiment depending on the size of the plant and the branch borne is of utmost importance. The undermentioned spacings for different varieties are worth practising :—

Variety	*Spacing*	*No. of plants/acre in* *sq. system*	*hexagonal system*
Amritsagar	8′	680	782
Safri	9′	538	618
Champa	10′	435	500
Singapuri	7′	889	1112
Agniswar	9′	538	618
Kabri	8′	680	782
Kachakala	10′	435	500
Aitakala	11′	360	444

DIGGING OF PITS

It is needless to say that the pits should be of good size not only to be big enough just for planting but big enough to keep provision for the enlargement of the bases of the plants within a few months' time. It is to be remembered that the suckers require room for proper growth and development. The Horticulturists have found the pit dimension of $2\frac{1}{2} \times 1\frac{3}{4}$ ideal, for banana. A smaller pit having a diameter of 2′ and depth of $1\frac{1}{2}$′ may also serve the purpose quite satisfactorily except in such soil which is sufficiently fertile.

MANURING

That banana plant is a gross-feeder and produces maximum possible amount of food per unit area of land is not usually been taken into consideration by most planters. But thanks to the growers of Munshiganj who have long been paying great attention to proper cultivation of banana. They consider banana as their main cash crop and take care for providing the plants wiith sufficient nutrients. The site of the pond and canal is commonly used by them for earthing the bases of the plants, 300—500 mds., of this per acre not being considered as over-dose, when there is sign of unsatisfactory growth they apply about 2 baskets of old cow-dung and 1/2 to 1/4 seers of mustard cake per plant. The following doses of manures per pit have been found satisfactory in Dacca Farm area:

Farmyard manure or cow-dung	...30 lbs.
Wood-ash	... 4 lbs.
Bone-meal	...1/2 lb.
Oil-cake	...1 lb.

One-third to half of this may be applied broadcast throughout the field and well-mixed with soil at the time of land preparation. The rest is applied in the pit. During the 3rd and 4th months after planting sulphate of Ammonia may be applied 1/2 to 3/4 lbs., in all, split up into 2—3 parts and used as many times by top dressing, with an interval of a fortnight or so. Superphosphate is sometimes used at the rate of 1/4—1/2 lb. per plant during the 6th or 7th month.

The Amritsagar banana which is the main variety in Dacca Farm, responds well to these manurial applications. Singapuri banana should receive a higher dose. Banana crop preceded by a green manuring crop is expected to yield a richer harvest.

Stout and healthy suckers that have not attained much height but have well-developed basal parts are suitable ones for planting. The length of the sucker may be 2½′—3½′ under normal conditions. All old roots attached to the rhizome are clipped off and either half of each of the leaves is cut off or the leaves are completely cut back to the bases of the petiole, the latter method being preferable. The suckers are thereafter planted in the pit taking care that the base of rhizome is completely submerged in the pit. The most important task that awaits grower's attention after spring planting and during 2 subsequent months in the arrangement for profusely irrigating the plants. Flood irrigation once in a fortnight is considered sufficient. This sort of irrigation is possible where there is a power pump, Persian-wheel or a Don. Under conditions which do not provide for appliances that may be used for flooding the plots with water it would be all right if about 8—12 gallons of water are applied to each plant twice in a week.

One important point which should demand special attention of the growers is the orientation of the plants, that is, to have all bunch of fruits hanging on one side of the trees. When the bunches can be made to hang on one side only the following advantages can be achieved :—

(*i*) The uniformity of flowering at one side imparts beauty to the plantation.

(*ii*) The watching and harvesting become easier.

(*iii*) When the inflorescence is allowed to hang on the northern side of the plant the advantage secured is that the sun-rays cannot give burning effect on the fingers.

The orientation can be accomplished as far as the first crop is concerned by planting suckers with the cut sides of the rhizome in one direction. The inflorescence appears on the side opposite to the cut surfaces. Therefore, the cut-surfaces should be placed on the southern side.

AFTER-CARE

Generally speaking, the banana plants have a comparatively shallow root system and it is, therefore, not advisable to cultivate the soil too deep after planting. About 4—5 days after every flood irrigation the garden may be held by means of hand hoe or khurpi. The weeds require to be controlled from time to time, else they would extract a substantial portion of the nutrient supplied to the shallow rooted banana plants.

Under usual conditions, numerous suckers are produced by each plant. If these suckers are allowed to grow side by side with the parent plant they are sure to take away much of the food-materials from the soil. The suckers are not therefore allowed to raise their heads and they are cut back to the ground level whenever the weeding or mulching operations are conducted. One sucker may be allowed to grow at the sight of the emergence of the inflorescence which will be about half of the size of parent when the fruit is ripen.

Banana plants, weak and shallow rooted as they are, require support when they bear the bunches and at the time of storm. Each of the plants is, therefore, given supports with bamboo stake by dipping the base of the stake deep into the soil and binding it with the plant.

While young leaves should never be cut down, the old and dry ones also need not be removed from the plant. They may rather be kept attached to the pseudostem by binding with one of the leaves, to be used for dumping at one place at the end of the harvest and burnt to ashes or com-

posted. It may, however, be remembered that old leaves should occasionally be removed if there is possibility of these becoming the host to termites, pests and diseases.

HARVESTING

The time required from planting of sucker to the maturity of the fruit borne by it varies to a great extent from variety to variety, the cavendish banana (Singapuri) usually taking the shortest time. Since it is worthwhile to give an idea as to how much fruit is borne and what time is required by an individual variety, let us follow the undermentioned figures observed in Dacca Farm by the author himself :—

Variety	*Weight of the bunch*	*Time spent from planting to harvesting*
	Lbs.	*Months*
Agniswar ...	7—12	12—15
Amritsagar ...	18—26	9—12
Botur Aita ...	30—36	15—20
Champa ...	17—29	9—11
Dudhshar ...	6—10	12—15
Kabri ...	15—29	12—16
Kachkala ...	21—32	12—15
Safri ...	13—22	11—13
Shangi Aita ...	34—60	14—20
Singapuri ...	25—38	8—10

The bunch of banana is harvested as soon as (*i*) the fruits are fully developed (*ii*) the upper fruits show signs of changing to a light green to yellowish green colour in most varieties (*iii*) the pistil attached to the apex of the fruit is dried, and (*iv*) the fruits tend to show more or less edgeless and almost round shape. The per acre production of banana differs from variety to variety, the approximate production under Dacca Farm conditions having been found as follows in major varieties :—

Amritsagar	... 220 mds.
Champa	... 200 mds.
Kabri	... 150 mds.
Safri	... 150 mds.
Singapuri	... 350 mds.
Agniswar	... 100 mds.

MARKETING

As all the districts produce bananas to a moderate extent export of banana from one district to another is not normally found. Transportation by means of boat and bullock-cart is common and banana are placed in loose condition. There is seldom any package and whenever there is any such it is generally a basket made of bamboo. Bananas go to West Pakistan by air ; but the freight charges are so high that cheap bananas have to be purchased by its counterpart at an exceedingly high cost. Transport by means of sea-going vessels is desirable and such a transport taking 7—8 days could benefit both the producers and the consumers resulting in an increase of production.

In storage and during transportation the temperature most suited is 53°—55°F. Smearing the cut-end of the peduncle with dilute copper sulphate solution or applying melted paraffin helps the fruits remain fresh longer and ripen with an attractive colour, according to Hayes.

ROTATION OF CROP

The second crop, that is, the crop got from the ratoon, gives almost as much yield as is obtained from the first. However, from the third year the amount of production falls down to such an extent as to make the crop uneconomic. Therefore, the banana plants are to be kept on the same plot for 2 consecutive years only, thereafter selecting another plot for fresh planting. The original plot may be bought once again under banana after an interval of about 2 years during which time crops like mustard, legumes, etc. can be grown there which do not need excessive food materials from the soil.

PESTS AND DISEASES

(1) One of the formidable enemies of banana is BANANA BEETLE. This small pest eats away leaves and tender skin of fruit at the early stage with the result that scars are formed on the leaves and fruits. Where there is possibility of the attack of this type of pest, it is advisable to start spraying the plants with lead arsenate 1 lb. of this being mixed with 100 gallons of water, with an interval of a fortnight or so between two sprayings, from the early days. After the emergence of inflorescence the plants can be sprayed with D.D.T.

(1 lb. of 5% dispersible powder being dissolved in 100 gallons of water). The spray may be repeated after 10 days.

(2) Bananas have occasionally been found to spilt on the skin. Such skin split is caused by a pest known by the name Banana *Rust Thrip*. This can be controlled by the following ways :—

(*a*) Bagging the bunches in gunny bags.

(*b*) Dusting with Nicotin dust fortnightly during the whole growing period of the bunch.

(*c*) Dusting with 2% D.D.T. or a mixture of D.D.T. and Nicotin.

(3) Banana grass-hoppers, sometimes, do much damage to the leaves. In order to trap and kill such hoppers poison baits are prepared and spread in the plot. The following formula will give a preparation for use in one acre :—

Agrocide—7 lbs.
Rice Kura or Wheat bran—25 lbs.
Mollasses—5 lbs.

(4) Of the diseases of banana *Panama Disease* is the most destructive and contagious one. This disease is termed as Banana wilt too caused by a soil borne fungus, Fusarium Cubanes. The prominent symptoms of this disease are : (1) the rapid wilting of the leaves, (*ii*) Yellowing of the lower or other leaf-blades, (*iii*) Progressing of the yellow-colour inwards the mid-rib, (*iv*) buckling of the leaf petiole at some point between the pseudostem and lamina the leaf hanging pendent from the point. While there is no effective control of this disease the following remedial measures may be adopted to check its expansion :—

(*a*) Destroy plants, suckers, etc. by burning.

(*b*) Sterilise soil of vacant pits by sprinkling formaldehyde solution (1150) or burning strew or leaves.

(*c*) Do not grow banana on the spot for at least two years.

Anonymous, received through the courtesy of CH. MUSHTAQ AHMAD BAJWA, *Vakiluz-Ziraat, Tahrik-i-Jadid, Anjuman Ahmadiyya, Rabwah.*

SOME AGRONOMICAL STUDIES ON BANANAS

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Banana is a plant of tropical climate, characterized with high temperatures and humidity in the atmosphere. It is a gross feeder and requires lot of manuring.

Many species and varieties of this fruit plant are being grown in various tracts. Some of them are thick stemmed (Pseudo-stem) and tall growing, some are tall and slender while others are dwarf or semi-dwarf and stout. They show different responses to the varying climatic conditions obtaining at different places according to their morphological characters. In canal colonies of old Punjab region where hot and high winds blow in the summer, dwarf or semi-dwarf varieties are more successful than taller varieties because they are less subjected to the high velocity winds.

Planting season and planting distances have a direct bearing on the profitable cultivation of bananas. Planting in a wrong season will mean very little success in planting or its total devastation as the little young ones would be unable to withstand the vagaries of inclement weather. The studies under report were carried out in order to find out the optimum season of planting and the distances from plant to plant each way.

Experimental material and methods

Approximately uniform sized suckers of selection numbers 7, 8, 9, 10, etc. varieties furnished the experimental plant material.

S_7, S_8, S_9 S_{10} etc. selection numbers were given to the plants which were left over in our plant collection block from the banana trials carried out during 1936-42. Their identity was lost with the passage of so much time and it was thought advisable to give them the selection numbers. The selection numbers S_7, S_8, S_9, S_{10}, are identical with each other in all respects and they seem to belong to one variety, most probably 'Rajapuri'. This is a semi-dwarf and with stout pseudo-stem and is more successful than any other variety in this region. Other details of the experiment are as follows:—

I. Season of planting:—
 (i) Spring (April)
 (ii) Monsoon (August)

II. Spacing: (i) 7×7 ft.
 (ii) 5×5 ft.

III. Variety: Rajapuri

IV. Layout: Randomized.

V. Number of plants in each treatment-6

VI. Number of replications 3

The data on the following aspects was collected:

1. Success of plants (Survival)
2. Height of the plant.
3. Girth measurements of pseudostem.
4. Number of suckers.

Height of the plants was measured right from the ground level to the point from where the inflorescence emerages in between the upper young leaves. Circumference measurements were taken with a steel tape at one foot from the ground level. For recording the number of suckers all big and small suckers were counted.

Presentation of data

The data collected on various aspects such as success in planting, final height, girth and number of suckers produced are summarized as follows:—

TABLE I—*Height of plants (Ft.)*

Replications	Set I T_1	Set I T_2	Set II T_1	Set II T_2
1.	5.25	4.25	4.07	4.00
2.	4.17	5.84	4.08	4.12
3.	4.18	4.39	4.29	3.39
Total	13.60	14.48	12.44	11.51
Average	4.53	4.83	4.15	3.84

TABLE II—*Girth of plants (Cms.)*

Replications	Set I T_1	Set I T_2	Set II T_1	Set II T_2
1.	56.03	37.69	40.13	37.02
2.	41.52	56.03	37.62	40.72
3.	42.70	44.27	42.19	32.18
Total	139.25	137.99	119.94	109.92
Average	46.42	46.00	39.98	36.64

TABLE III—*Number of suckers.*

Replications	Set I T_1	Set I T_2	Set II T_1	Set II T_2
1.	3.83	2.33	3.17	2.50
2.	2.33	2.50	1.83	2.33
3.	4.66	3.17	2.50	1.50
Total	10.82	8.00	7.50	6.33
Average	3.61	2.67	2.50	2.11

Set I — April Planting.
Set II — August Planting.
T_1 — Spacing 7×7 ft.
T_2 — Spacing 5×5 ft.

I. Success in planting

Out of 36 experimental suckers planted in April, 1958 six plants died after a few days and in this way the success of planting in April was 83·33 per cent. August planting was cent per cent successful.

II. Height of the plants

The final height measurements of the banana plants under different treatments are set out in Table I. A reference to this table shows that the plants which were put down in April attained more height as ompared with those planted in August. Under spacing treatments the plants at 5×5 ft. distances had grown slightly taller than those planted at 7×7 ft. distance. The results are, however, statistically in-significant.

III. Girth of the Pseudostem

Girth values for the experimental banana plants have been arranged in Table II. A statistical examination of this data revealed no difference in girth due to planting season or the spacing treatments; however, April planting seems to have slightly more favourable effect on the circumferential growth of the plants.

IV. Number of Suckers Produced

Data on average number of suckers per stool in all the treatments have been presented in Table III. The plants put down in April gave rise to more suckers as compared to those planted in August. The differences, however, fall short of statistical significance.

Discussion

Banana is strictly a tropical plant and as such it requires a hot and humid climate and is susceptible to frosts. Unluckily our climate (in former Punjab) is very dry in summer and occurrence of frost is also very frequent during December—Feburary. This type of climate is not at all suitable for growing banana—but we have to grow bananas for meting out local requirements or we have to import it from neighbouring country at the cost of our foreign exchange which otherwise could be utilized for more beneficial purposes The question arises, "HOW TO GROW IT." We have to explore all possibilities, suitably sheltered places, hard varieties and suitable cultural practices for successful cultivation of this fruit.

These studies were undertaken in order to find out the optimum season for planting the banana and the distances between the plants.

The planting success was 100 per cent in August planting while about 17 per cent of the plants died from April Plantation. The month of April is followed by the hottest and the driest months of May and June which is a perilous period for a humid loving unsheltered banana plant. Obviously the death of six plants out of 36 was due to very harsh weather conditions coupled with shortage of irrigation water.

August is followed by a period of milder temperatures and high humidity in the atmosphere which is conducive to the normal setting of the plants, especially bananas.

Regarding growth of the plants, the suckers planted in April made better growth as compared with those planted in August. Optimum temperatures and high humidity during monsoon and autumn season after a short rough period of May and June had a beneficial effect on the growth of April planted suckers, while those planted in August had little time for growth *i.e.* up to November only. Their growth was checked by low temperatures of winter. Frosts also had a very deleterious effect on their growth.

Similarly the number of suckers is slightly higher in case of April Plantation. This is also due to the fact that the monsoon following the hot and dry period of May and June proved a boon for the plants which apart from making a good growth threw out a large number of suckers.

The data pertaining to the productivity and the quality of the fruit has not been given in this article for the fear that instead of being useful it might be misleading because the experimental plants were unsheltered and quite exposed to the inclemencies of weather and irrigation water was also not available in as adequate quantities as are required by bananas.

Summary

The studies embodied in this paper were aimed at finding the suitable season for planting the bananas and to ascertain the proper planting distances in the canal colonies of the former Punjab Province.

The studies were conducted in the Experimental Fruit Garden, Lyallpur. The experiment was laid out in a randomised block system. There were three replications and six plants under each spacing treatment. Two seasons of planting *viz.* April and August and two planting distances 5×5 ft. and 7×7 ft. were tried.

Planting success, average maximum height and girth and the average number of suckers per stool were recorded.

Although all the results are statistically insignificant yet the trend of the results go in favour of April planting. March planting might be still better.

There are no appreciable differences between the two spacings tried.

Acknowledgements

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THE BANANA IN EAST PAKISTAN

By

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AN IMPORTANT FOOD

Bananas are growing in almost every home yard in all parts of East Pakistan. Fruit matures throughout the year and is an important item of the diet of the people. It is the most easily grown and economically produced of all the fruits.

88,800 acres are made up of the scattered plantings, only a few of which are commercial in size. The 14,87,400 tons of fruit reported produced include the cooking types which far outweigh dessert types.

The banana is an excellent energy food source. It contains vitamins A, B, C and is rich in essential minerals. The fruit may contain as much as 20% sugar.

One hundred pounds of fruit per capita and fruit for export is the future goal. This will require plantings on about 500,000 acres together with improved cultural and distribution practices, and the selection of more productive varieties.

Plantain type starch banana are widely produced. They are cooked and are an important source of food. They are available in many villages throughout the year but are most plentiful during March to June.

There is an interest in the Comilla--Chittagong area to grow bananas for shipment by boat to Karachi. This may require the use of a more hardy variety such as the Dwarf Cavendish which requires a period of ripening after being removed from the plant. It is also a heavier producer than the Munshiganj variety called Amritsagar.

Varieties*

Twenty varieties have been tested by the Horticulture Section of which four only are being propagated for planting.

Amritsagar

The Amritsagar (Munshiganj) is a medium size fruit. The fingers being about one and one-fourth inch in diameter and five to six inches in length. A bunch may contain about seven hands and weigh about seven seers or from fourteen to twenty-two pounds. Three bananas will weigh about one pound. Growers receive about eight annas a seer for this fruit. The plant is semi-dwarf growing about ten feet tall. Maturity is during late winter, January to April, but in Munshiganj summer fruit is also produced. Fruit maturity is dependent upon the time the sucker was planted and the quality of fruit is dependent upon the care it received. Some fruits of the Amritsagar variety are found on the market almost all of the year.

Shafri

The Shafri or Sapri fruit is straight and round and is a popular variety. It is grown in all parts of the Province but does not do well in the red soil area. It is known as Malbhog in the Rangpur area and as the Anupam at Rajshahi. The principal maturrity time is early summer.

Champa

The Champa variety is a small fruit about three to four inches long and about an inch in diameter. It has a pleasant sour sweet taste. An occasional seed is found present in the fruit. There are many fruits on a bunch. A bunch may weigh fifty pounds. The Champa is found growing in most parts of the Province. There is a long maturity season of late winter and early summer.

DWARF CAVENDISH

(Musa Cavendishii)

Canary Island or Singapori. This fruit is the most resistant to cold of all banana varieties. It was discovered in North Central Burma. It is grown commercially in Lebanon and other Mediterranian countries. The Horticulture Section has conducted a test on this variety compared with the Amritsagar and found it

*Dr. L. H. Baily classifies bananas as follows:
Musa Sapientum-banana eaten raw.
Musa Paradisiaca-plantain to be cooked.
Musa Cavendishii-dwarf with edible fruit.

produces more heavily. The fruit is better adapted to shipping since it requires several days' ripening and coloring after removal from the plant. Two to three-day gas room treatment is standard in Lebanon for this variety. Plantings of the Dwarf Cavendish are usually retained for seven years in Lebanon where second year production is usually heavier than the fruit year. This fruit matures in early April if suckers are planted by June 1. Testing and research should be continued.

Cooking Banana Plantain Type

Three varieties were tested at the Horticulture Section, Anaji Kala, Bherardog and Choalpoush. No recommendation was made.

Country Varieties

There may be several hundred variations or types of bananas the growth of which would be discontinued or replaced if improved or selected varieties such as Amritsagar, Shafri or Dwarf Cavendish were available. Most Sub-Divisional Agriculture Officers say they have annual need of ten thousand or more suckers for sale to cultivators.

CULTURE :

(AMRITSAGAR VARIETY ONLY)

Planting Time

Where irrigation facilities are available, planting is done from early February or when there is enough rainfall in April or May or at the start of the Monsoon rains. Banana suckers may be planted on the sandy loam soils with fair success at any time if water is available.

Suckers are available in greatest quantity following the removal of the fruit at peak maturity period of April, May and June.

Select and plant only strong suckers of known variety and parentage. Strong suckers planted in April or May after the first rain when well cared for with adequate water fertilizer and cultivation will mature their fruit in March the following year.

Fruit Harvest

Experience by the cultivator in observing the filling out of the fruit and in the change in color of some fruits from green to yellow will serve as a guide for cutting the bunch and placing it in a protected shaded place for coloring. Placing the bunches in a closed box or barrel where the natural gases given off by the fruit are accumulated, hastens a more uniform ripening process. The old banana stock is cut down at the time of cutting the fruit bunch.

Sucker Management:

When a new sucker is planted new buds begin to form out of the rhizone or root stem. During the season of growth of the mother banana plant there may be as many as ten young suckers to develop and grow. These must be cut off at the ground level several (4) times during the year in order to prevent their competition with the mother plant.

Sucker Production

When the fruit is harvested and the mother plant is cut down, all of the suckers are allowed to grow. In six to eight weeks they are 30 inches or more high and ready for transplanting.

If a second crop is to be grown, one best sucker may be left for another year's production. This sucker should be permitted to grow from the time the mother plant blossoms and not cut off. Commercial plantings are usually entirely renewed after two years and the area used in a rotation of other crops.

Suckers like other plant materials, are perishable and should be protected against wind and sun. However, suckers will survive several weeks' storage in shade and still grow. Good practice is to plant as quickly as is practicable after digging.

All exposed leaf surface is removed. Roots are clipped back to the rhizone. New roots will grow after planting.

Location

Banana plants must be free from floods and on soil that is well sub-drained. Provision for surface drainage away from plants is needed on the clay soils during the Monsoon. A deep sandy loam soil is best but fair crops of Amritagar and Cavendish are harvested from plants on the red clay soils of Tejgaon. The raised land of the village or the banks of reservoirs are ex-

cellent locations for banana. Protection from severe winds is desirable. As water becomes available for irrigation much of the Jessore, Kushtia and Chittagong Hill Tracts can be planted to banana with expected success. Every city and country home should have banana plants both for fruit and for their ornamental beauty.

Planting

Bananas are frequently planted on a triangle or square about eight feet in each direction. Prepare the entire area of soil as for any other crop. Dig large holes in more difficult soils, smaller holes are ample in good soil. Dig a hole 2½ feet long and 2½ feet wide and 1½ feet deep. The banana roots are shallow feeders and will respond to large applications, 200 maunds of cowdung an acre. Prepare a mixture of surface soil and compost or well rotted manure of equal parts, for use in refilling the hole. Settle with water and let dry out for a day before planting. Do not permit a basin or low area to remain around the plant to hold water. This may rot the plant.

Fertilization

In planting or in the care of a banana plant the following recommendation is given:

30 pounds of well rotted cowdung or other manure may be used in the planting hole. Fresh cowdung or other manure may be used if put on top of soil or worked into surface soil. The following fertilizer materials are frequently used in addition to rotted cowdung, mixed with the soil used in the holes prepared for planting.

4 pounds of wood ash (kitchen etc.)

½ pound bone-meal.

1 pound oil-cake

¼ pound of triple superphosphate.

½ pound sulphate of ammonia as two applications: ¼ pound at planting time and ¼ pound before the last rains of September. This last is applied as a surface application.

The rotted cowdung, wood ash, bone-meal, oil-cake and triple superphosphate is all best worked into the top one foot of the soil before planting. Silt from reservoirs or river banks is an excellent top dressing for the banana garden soil. The banana will respond to heavy applications of organic manures, nitrogen, phosphorus and potassium.

Irrigation

The soil in the holes prepared for planting should be irrigated to settle before planting. The newly planted suckers should be irrigated to settle the soil into close contact with the newly emerging roots. The new plant will require water two to three times a week depending upon the weather conditions until roots develop. Irrigations every two weeks are adequate after roots have developed for the early period of growth until rains come. If water is to be carried, 8 gallons to a plant weekly may be sufficient to keep it alive and to start growth.

At least one thorough irrigation each month is essential during the dry season when rains do not occur, if high production is to be achieved. Irrigation management requires experience and judgement on the part of the cultivator. Irrigation practices should be adjusted to each particular land and plant situation.

Yields

Planting on eight-foot centers will permit 680 trees an acre. An average yield is seven seers a plant. Many growers report ten and eleven seers a plant, 15 pound a plant will equal slightly more than 10,000 pounds or a gross sale value of about Rs. 2,500.

GARDEN MANAGEMENT:

Miscellaneous

Use braces where winds are severe.

Plant cut side of rhizone on south side to influence blossoming uniformly on the north side.

Keep grass and weeds eliminated but do not cultivate the soil deeply enough to disturb the shallow roots.

Provide a wind break if at all possible.

In a hot dry climate provide partial shade if at all practical. Treat blossoms and young fingers with D.D.T. spray for banana beetle control.

For particular directions ask your Plant Protection Officer or Union Agricultural Assistant or Horticulture Nursery.

Banana leaves are injured at temperatures of 31°F or below and banana plants may be killed to the ground by temperatures of 28°F for a few hours. Hail and sleet has caused damaged to exposed fruit. Mean average winter temperatures below 50°F decrease the fruitfulness of the banana. Research is needed to determine the maximum favourable temperature for banana production.

The work done at the central nursery by the Horticulture Section on variety production tests is commendable. This is an excellent start. The importance of the banana and its possible rapid increase in production suggests the need for further study and research on this fruit. Yields of the Cavendish dwarf variety in Lebanon are commonly thirty to fifty pounds.

THE AMERICAN BANANA

(MUSA ACUMMATA)

Gros Michel Variety

The banana is presumed to have originated in the South Asia area and has been taken to most tropical countries of the world. Alexander the Great found it in India in 337 B.C. The Gross Michel variety is a sport which originated in Martinique and is grown extensively in Central America for export to the United States. A bunch of this variety may weigh seventy-five pounds or more. They are harvested green and ripened during their 30 days' shipment and storage period.

Banana represents one of the important export products of Central and South America and is an important item in the diet of most tropical peoples.

There are three serious diseases that attack the bananas of Central and South America. These diseases should be studied and prevention or control programs developed for East Pakistan.

1. Panama Disease (Fusarium Wilt) Panama disease has killed vast acres of banana plantations. It is a soil-borne fungus which attacks through the roots of the banana plant. A control by silting, flooding, and land fallow is not yet satisfactory.
2. Sigatoka (Cercospora leaf spot) Banana leaf spot is caused by an organism Mycoskhacrolla musicols fungus which kills areas of the leaves and thus destroys the fruiting of the plant. A light oils spray has given partial control.
3. Moke or Bacterial Wilt. Leaves become discolored and break down. Pulp of fruit decays. Control by disinfecting all tools used.

The presence of these and other diseases throughout the world indicates the dangers the important banana crop in East Pakistan may be subjected and the importance of having a trained technician Pakistani working in this field.

References

(*a*) Research data of Horticulture Section, GOEP. See Horticultural Section Officials for details of research.

(*b*) *Banana Disease Research*, United Fruit Company, N.Y., U.S.A.

(*c*) *The Banana in India*—Indian Council of Agric. Research.

PROGRESS REPORTS
ON
SOME HORTICULTURAL SCHEMES

Progress Report of the "Scheme on Propagation of Hill and other Deciduous Fruits in Murree Hills, Soon Valley and Salt Range" (Period 1952—61)

By

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AND

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It is an admitted fact that the economic conditions of the farmers of Murree Hill area can only be improved if they resort to growing of fruits rather than the farm crops which due to very small holdings, do not give economical returns to them. The cool and temperate climate of this tract, on the other hand, offers ample scope of fruit-growing particularly apples, pears, plums, apricots, walnuts, etc. But there were some serious problems which had handicapped the fruit development in this region in the past. Of these, the most important were the non-availability of reliable nursery plants and dearth of good varieties for propagation purposes. Although there were a few orchardists who possessed good scion varieties but were reluctant to propagate these themselves and also showed lack of interest even in extending their own plantations. In order, therefore, to promote general interest for fruit growing and to make available to the growers the best nursery plants of known pedigree, a scheme on the Propagation of Hill and Other deciduous fruits in Murree Hills, "Soon Valley", etc. was brought into operation in the year 1952. In order to achieve this end the project has been handled from all aspects which are essential for the sound development of the fruit industry in this region which is ideally suited for growing all the fruits mentioned above.

The followings are some most important activities of this scheme:

1. Establishment of Research Sub-Stations.
2. Production and supply of pedigree fruit plants.
3. Introduction of better fruit varieties.
4. Bud selection work.
5. Survey of Murree Hills for apple growing.
6. Classification and identification of existing fruit varieties.
7. Introduction and trials on new fruits.
8. Research on various problems of fruit culture.

1. Establishment of Research Sub-Stations

Murree Hills have an elevation ranging between 2000 to 8000 ft. and has an annual rainfall of 50 to 80 inches. Lower Hills are suitable for growing peaches, plums, almonds, loquat, persimmon, citrus, strawberries, etc., whereas apples, pears, walnuts, cherries can be grown on higher hills above an elevation of 4000 ft. It was therefore decided to establish two research sub-stations, one at Sunny Bank, Murree at an elevation of about 6500 ft. and other at Charrapani at an elevation of 3000 ft.

(*i*) *Hill Fruit Research Sub-station, Sunny Bank, Murree.*—An area of 4 acres out of 7.5 acres previously known as Scott's Nursery was obtained on lease from Municipal Committee, Murree for establishing a Research Sub-station at Sunny Bank, Murree. This area was levelled and divided into 8 blocks from A to H. The plantation work at this centre was first started in spring, 1954 and continued in the subsequent years; 2.5 acres of remaining portion of Scott's Nursery adjacent to the Hill Fruit Research Sub-station was handed over to us by the Municipal Committee, Murree in the year 1960. Levelling of this area, construction of retaining walls and layout work is in progress. As soon as this work is finished,

planting of new varieties will be taken in hand. The details of the varieties planted at this Sub-station are given inTable I.

TABLE I

Showing the Varieties Planted at the Hill Fruit Research Sub-Station Sunny Bank, Murree

Block	Kind of Fruit	Varieties Planted	
A, B, C & New Area.	Apple	Rome Beauty	New Zealand
		Macintosh	"
		Golden Delicious	"
		Amri	Quetta
		Kidd's Orange Red	New Zealand
		Kandhari	Quetta
		Kulu	"
		Mashhadi	"
		Banki	Murree
		Delicious	"
		Delicious	"
		Red Delicious	"
		Amri	"
		Delicious	"
		Beauty of Bath	"
		Red	"
		Golden Russet	"
		Red No. 1	"
		Red No. 3	"
		Winter Greening	"
		Ribston Pippin	"
		Spotted Red	"
		Delicious (Lal Amri)	"
		Saharni	"
		Delicious (Lal Amri)	"
		Sturmur	New Zealand
		Granny Smith	"
		Giant Jeniton	"
		Red Astrachan	"
		Laxton Epicure	"
		Idared	"
		Kapai Red (Jonathan)	"
		Kempton	"
		White Winter Pearmain	France
		Grims Golden	U.S.A.
		Winter Banana	Quetta
		Yellow Newton	"
H & New Area	Pears	Samar Kandi	"
		William's Bonchretien	New Zealand
		Winter Cole	"
		Leconte	Tarnab
		Kieffer	"
		William's Bartlett	"
		Bartlett	Quetta
		Louise Bonnede Jersey	New Zealand

Block	Kind of Fruit	Varieties Planted	
		Packhm's Triumph	New Zealand
		Baggu Gosha	Murree
		Pear English	,,
		Conference	New Zealand
		Winter Nelis	,,
		Beurre Hardy	France
		Beurred Ajon	,,
B	Peach	May-Flower	Quetta
		Quetta Shaleel	,,
		Wiggins	Tarnab
		Babcock	,,
		Peregrine	,,
		Elberta Early	,,
		Elberta	,,
		Golden Jubilee	,,
		Rochester	,,
		6-A	,,
		Red French Early	Murree
		Red Leaf	,,
A	Plum	Samli	Murree
		Duke	Quetta
		Wickson	Murree
		No. 1	Tarnab
		No. 3	,,
		Robio	,,
		Victoria	Murree
		No. 7	Tarnab
		Ganzales	,,
		Methley	,,
		Fazli Manani	,,
		Green Gage	New Zealand
A	Apricot	Charmaghzi Early	Quetta
		Large Red	,,
		Nari	,,
		Nuri	Murree
		White No. 1	,,
B	Almond	Thin Shelled	Quetta
		Thick Shelled	,,
E	Persimmon	Seedless	Mardan
F	Walnut	Kaghzi No. 1	Murree
E	Stock Plants	Tor Alu	Quetta
		Bitter Almond	,,
		Shaker Saib	,,
		Crab Apple	,,
		Quince	,,
		Mahaleb Cherry	,,
		Amrat (Pear)	,,
		Ananghe Cherry	,,
		Wild Apricot	,,

Block	Kind of Fruit	Varieties Planted	
C & H	Strawberry	Blakemore	U.S.A.
		Missionary	,,
		Klondyke	,,
		Superfection	,,
		Peshawari	Peshawar
		Samli	Murree

Most of the plants at this sub-station which were planted in the initial stages have started fruiting, while others are progressing well and are likely to come into bearing in the next few years. From the observations made so far, following tentative conclusions can be drawn:—

Apples.—Growth of the plants is very slow and thus only a few varieties have come into bearing. Rains, late frost and hails affect setting of fruit and dropping of flowers. Hails during September and October also damage the fruit. Effective, easy and cheap method of covering the plants will have to be evolved to save the fruit from the onslaught of hails.

Pears.—Plants of all the varieties are quite healthy but the rate of growth is very slow. Kieffer, Leconte and William's Bartlett varieties have come into fruiting. At this stage it is not possible to say which of the varieties will do well.

Peaches.—Plants are severely affected by leaf curl and aphids. In spite of our best efforts it has not been possible to control fungus disease and the pest. Fruit of almost all the varieties ripen during July and August *i.e.,* during monsoon rains. Although the fruit develops its size and colour normally it turns insipid due to heavy and continuous rains.

Plums.—Growth and development of the plants is quite normal. A few of the varieties which ripen before the start of rainy season are excellent in quality. Varieties ripening before or after the rains are likely to do well. English varieties like Green Gage, Duke, Victoria, President, Coe's Golden Drop etc., which ripen late and are fleshy types will succeed at this sub-station.

Apricots.—Plants of almost all the varieties are growing very well and fruiting normally. Quality of the fruit is also very good. We have only five varieties at this sub-station, therefore efforts will be made to import more varieties for trial.

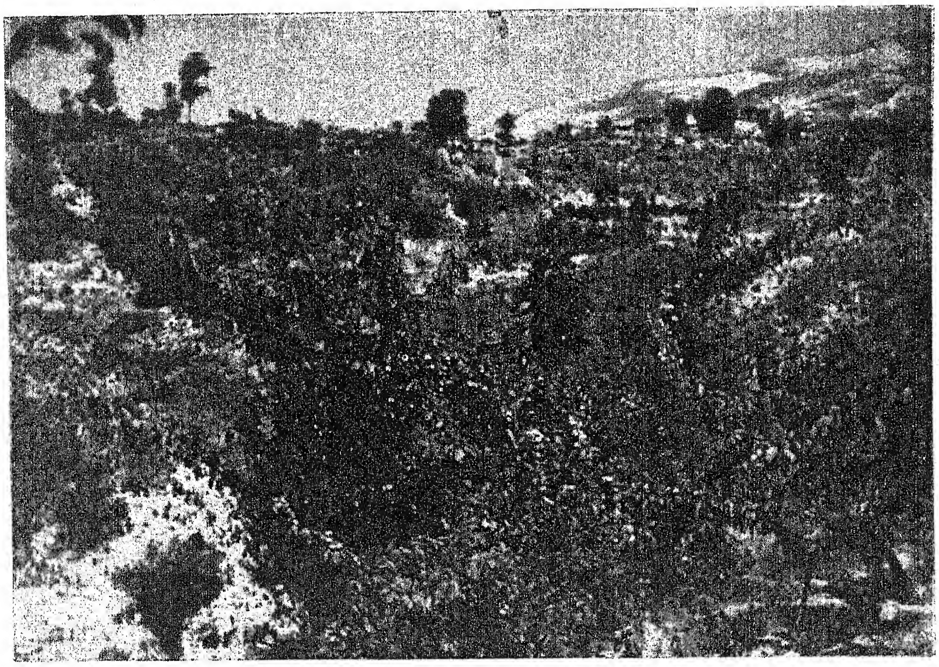
Almonds.—Cultivation of this fruit has proved a total failure in the Murree Hills.

Almonds require a dry climate whereas Murree experiences annual rainfall of 50 to 80 inches. Some of the plants have died while others are at the verge of death. During the last several years we have not got a single ripe fruit from any of the trees.

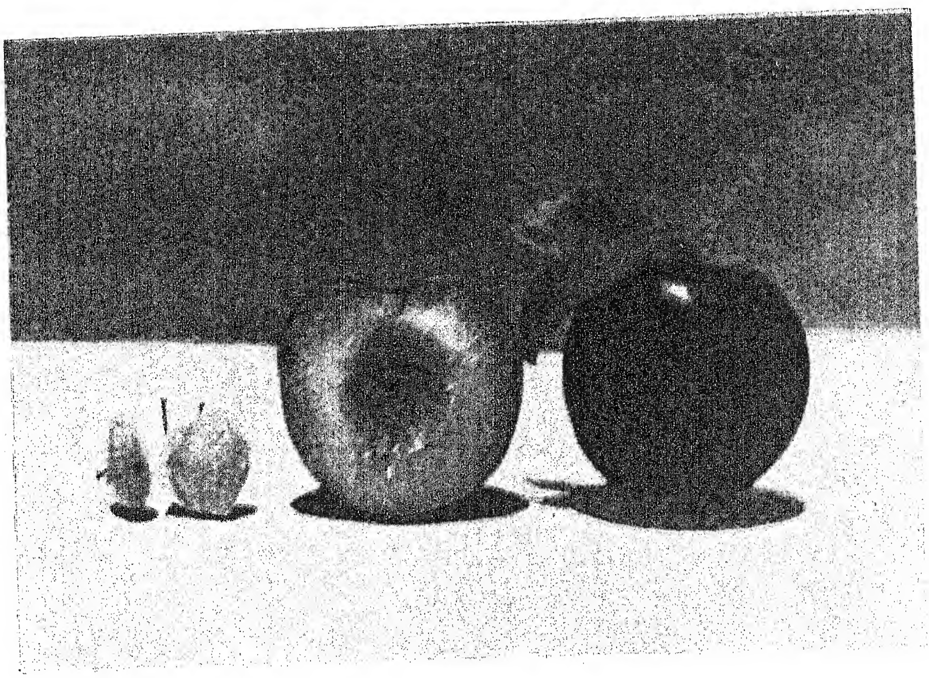
Persimmons.—Seedless Mardan variety was planted only last year. At this stage it is not possible to say any thing as its behaviour has not been studied.

Strawberry.—Plants of all the varieties are not showing healthy signs. Whatever fruit is set is damaged by rains as the ripening season coincides with monsoons. Plants of all the varieties have put up very poor growth.

(ii) Hill Fruit Research Sub-Station, Charrapani.—At this place about 60 kanals culturable land was taken on rent in August 1954 from some private growers. This area has been increased to 62 kanals from 1961. The elevation of this site is about 3,000 ft., and is fit for growing stone fruits, loquats, persimmons, citrus, avocados, strawberries etc. The entire area at this sub-station has been divided into 14 separate Blocks from A to N. Different varieties of the above-mentioned fruits have been planted to study their performance at lower elevations. The list of the varieties which have been planted are given in Table II.



A Panoramic View of
Hill Fruit Research Sub-Station, Charrapani



Plum—Fazale Manani

TABLE II

Showing the Varieties of Different Fruits Planted at the Hill Fruit Research Sub-Station, Charrapani

Block	Kind of Fruit	Varieties Planted	
A	Peaches	May-Flower	Quetta
		Quetta Shaleel	,,
		Shah Pasand	,,
		Red Leaf	U.S.A.
		Elberta	Tarnab
		Early Elberta	,,
		6-A	,,
		R.F.Early	,,
		Rochester	,,
		Triumph	,,
		Peregrine	,,
		Golden Jubilee	,,
		Babcock	,,
		Wiggins	,,
B	Apricots	Nari	Quetta
		Charmaghzi	,,
		Large Red	,,
		Sandian Red	Murree
		White Charrapani	,,
		White Ghora Gali	,,
C	Plums	No. 3	Tarnab
		No. 7	,,
		No. 1	,,
		Ganzales	,,
		Robio	,,
		Fazal-i-Manani	,,
		Methley	
		Alu Bukhara	Murree
		Wickson	,,
		Victoria	,,
		Howard's Maracle	U.S.A.
		Green Gage	New Zealand
D	Almonds	Thick Shelled	Quetta
		Thin Shelled	,,
		Thin Shelled	Murree
K	Grapes	Cross 13/11	Lyallpur
	Pomegranates	Alak	,,
		Turkish	,,
		Hilali	,,
		Sayah	,,
		Seedless	Mardan
	Banana	S_1	Lyallpur
		S_5	,,
		S_6	,,
		S_8	,,
		S_{10}	,,
	Persimmon	Seedless	Mardan

Block	Kind of Fruit	Varieties Planted	
L	Loquats	Loquat	Lyallpur
		Loquat	Murree
		Loquat Seedless	Mardan
	Litchi	Litchi	Layllpur
		Litchi	Dera Dun
	Avocado	Avocado	California
		Avocado	Ceylon
I	Cherries	White Heart	Quetta
		Early River	,,
		Charehan	Murree
		Red	,,
		Yellow	,,
		Black	,,
J	Mandarin	Kinnow	Lyallpur
		Feutrell's	,,
		Early	,,
	Malta	Valencia Late	,,
		Washington Navel	,,
		Blood Red	,,
M	Olives	Memeli	Turkish
		Aynelik	,,
		Cakir	,,
A & I	Strawberries	Blakemore	U.S.A.
		Missionary	,,
		Klondyke	,,
		Superfection	,,
		Gem	,,
		Mastoden	,,
		Peshawari	Peshawar
		Samli	Murree

In addition to the above-mentioned varieties, the plants of the following varieties have been raised and will be planted at the Sub-Station shortly.

Kind of Fruit		Variety	From where imported
Peach	...	Golden Jubilee	U.S.A.
		Elberta	,,
Nectrine	...	Cardinal	France
		Cavalier	,,
Plum	...	French	U.S.A.
		Santarosa	,,
		Burbank	,,
		Beauty	,,
		Damson	,,
		Sugar	,,
		Satsuma	,,
		Green Gage	,,

Following tentative conclusions can be drawn from the observations made at this sub-station.

Peaches.—Plants are severely affected by aphis and leaf curl almost every year. Rate of growth and development of the plants and flowering is quite normal, but the fruit does not attain proper size on account of the attack of aphis and leaf curl. If we are able to control the above: mentioned pests and the fungus, very good peaches can be produced.

Plums.—Growth, development, flowering and fruiting is quite good. Quality of the fruit is also excellent. The only drawback is that the fruit is severely damaged by the insect pests.

Apricots.—This fruit is also successful at Charrapani. Insect pests attack the fruit when it is about to ripe.

Almonds.—Condition of the almond trees is very unsatisfactory. They have put on very poor growth and have not given any fruit. Main hindrance is heavy rains.

Grapes.—Grape cultivation at Charrapani has proved a failure and has thus been given up. Although the plants had put on good growth but never yielded reasonable crop. Ripening of the berries was also not uniform. Splitting of the berries without exception just before ripening was another problem in the successful cultivation of this fruit.

Pomegranates.—Plants have put on poor growth. Fruiting is also poor. Fruit splits before it is ripe.

Banana.—Banana cultivation has been given up after 3-4 years' trial. During winter the plants were killed by very low temperature and the frost without exception.

Persimmons.—So far we have got only one variety at this sub-station. This variety is yielding excellent quality fruit. It is proposed to plant a few more varieties.

Loquat.—Loquat plants of different varieties are making very good growth. Fruit is better in size and quality than the varieties already growing in the locality.

Litchi.—Litchi plants of both the varieties have been killed by very low temperature. During the period the plants were alive they never made any growth and were in very poor condition which clearly indicated that they were not suited to the climatic conditions prevailing at Charrapani.

Avocado.—Avocado plants of the two varieties have made very vigorous growth. Some plants of both the varieties are yielding good quality fruit. The only defect so far noticed is that the fruit of California variety turns black and is shed prematurely. So far Plant Pathologist, Agricultural College, Lyallpur has not suggested any remedy to whom the diseased fruit was sent.

Malta (Oranges).—One of the three varieties (Valencia late) started fruiting. This year (1961) the fruit dropped prematurely as Charrapani also experienced some snow and thus quality and maturity studies could not be undertaken. Conditions of the plants and flowering and fruiting is good. In the next few years more will be known about this fruit.

Mandarin.—Out of the two varieties, Kinnow mandarin which was planted in the year 1955, is fruiting. Quality of the fruit produced is excellent. Fruit produced in the plains is no match for that produced at Charrapani. Condition of the plants is also good. Due to humid climatic conditions plants are severely affected by citrus canker.

Cherries.—Plants are healthy but the rate of development is slow. So far no variety has started fruiting as the plants are 2 to 3 years old only.

2. Production and Supply of Pedigree Fruit Plants

Propagation work was started at both the substations in order to propagate plants of important scion varieties of apples, pears, plums, peaches, apricots, walnuts etc. In the first few years special efforts were made to sell the plants by launching grow more fruit tree campaign. For this purpose special staff was deputed from Lyallpur. In the later years, however, no special efforts had to be made as the Village-Aid staff proved very useful for the distribution of fruit plants. They also subsidised the cost of the plants by 50 per cent.

Nursery work at the Hill Fruit Research Sub-Station Sunny Bank, had to be stopped as the plants raised did not attain proper size due to very low temperatures and short growing period. During winter majority of the plants used to be broken under the load of heavy snow experienced at Murree. On the contrary plants raised at Charrapani attain very good size and thus have become very popular among the fruit growers of Murree Hill areas.

During the period under review as many as 72312 plants of different kinds have been distributed in addition to 27,861 strawberry runners of different varieties. The details of the plants of different varieties distributed is given here in Table III.

TABLE III

Showing the number of Plants Distributed from Murree and Charrapani

	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60	1960-61
Apples ...	238	1,066	4,224	5,796	13,478	13,247	12,621
Pears ...	...	91	158	791	603	1,042	3,262
Peaches ...	...	132	81	502	484	1,258	1,079
Plums ...	...	173	1,041	836	888	1,312	2,024
Apricots ...	...	64	261	670	1,611	1,112	1,157
Almonds ...	30	160	195	39	285	120	30
Walnuts ...	...	21	5	12	13	45	2
Citrus ...	...	...	...	...	...	8	37
Total ...	268	1,711	5,965	8,646	17,362	18,148	20,212
Strawberry Runners	4,231	4,980	6,200	600	450	4,850	6,550

3. Introduction of Better Fruit Varieties

An introduction of better fruit varieties from other fruit regions is one of the easiest and quickest methods of effecting improvement. At present there are only a few really good varieties in this region which can be used for propagation purposes. There is also dearth of early, mid and late season varieties with the result that fruit is available for a very short period in the market. With a view, therefore, to widen the scope of selecting better varieties for future propagation and to make the fruit available over a long period in the market, the work of introducing more varieties was also taken up. The number of varieties so far introduced are given below:—

TABLE IV

Showing the Number of Varieties Introduced So Far

Kind of Fruit	Number Introduced					
	Quetta	Tarnab	Newzealand	U.S.A.	Other Places	Total
Apples ...	4	...	13	...	...	17
Pears ...	2	3	7	...	...	12
Plums ...	1	7	4	1	...	13
Peaches ...	4	10	3	1	...	18
Apricots ...	3	...	...	...	...	3
Almonds ...	2	...	...	...	...	2
Stock plant (*a*) ...	7	...	...	...	...	7
Strawberries ...	...	...	...	5	...	5
Citrus ...	...	...	...	...	4 Lyallpur	4
Olives ...	...	...	...	...	3 Middle East countries	3
Pomegranate ...	...	...	...	...	5 ,,	5
Banana ...	...	...	...	...	6 Lyallpur	6
Persimmon ...	...	...	...	...	1 Mardan	1
Loquat ...	...	...	...	...	1 ,,	1
Litchi ...	...	...	...	...	2 India	2
Avocado ...	...	...	...	1	1 Ceylon	2
Total ...	23	20	27	8	23	101

Plants of all these varieties have either been planted at the Hill Fruit Research Sub-Stations Sunny Bank, Murree or Charrapani or at both places for a trial and selection purposes. Their performance is recorded regularly and the successful varieties will come on the approved list in due course for disribution to the growers.

In addition large number of varieties are expected to arrive for trial purposes from England, France, U.S.A., New Zealand during the next few years.

4. Bud Selection Work

For want of Government plantations under Hill fruit varieties in this part of the province procurement of reliable bud-wood of the desirable fruit varieties for propagation purposes became a great problem. The selection of suitable trees of the best varieties for this purpose was, therefore, taken up through the systematic bud-selection work and identification and description of fruit varieties. Because of the vital importance of this work in the production of fruit nursery plants, utmost care was exercised in selecting, labelling and then obtaining bud-wood from the selected trees to ensure not only the quality of fruit plants but also their pedigree.

In this connection the number of trees marked and labelled in various gardens since the inception of the scheme is given in Table V.

TABLE V

Showing the Number of Trees Marked and Labelled in Various Gardens of Murree Hills up till June 30, 1961.

Kind of Fruit trees		No. of trees marked and labelled	Villages where labelled
Apple	...	80	Murree, Samli, Sandian, Charehan, Rawat, Aliot, Ghel, Potha and Sui.
Pears	...	27	Murree, Ghora Gali, Samli, Sandian, Charehan and Bhamrot.
Plums	...	53	Murree, Aliot, Ghora Gali, Bhamrot, Bansra Gali, Samli, Sandian, Charehan, Charrapani and Potha.
Apricots	...	42	Murree, Aliot, Ghora Gali, Bansra Gali, Samli, Sandian, Rawat and Charrapani.
Peaches	...	8	Murree, Bhamrot, Sandian and Charehan.
Almonds	...	6	Ghora Gali and Potha.
Cherries	...	14	Murree and Charehan.
Walnuts	...	8	Murree, Sandhian and Potha.
Loquats	...	5	Choa-Saidan Shah (Salt Range).
Total	...	243	

As a result of the bud selection work carried out the following 33 varieties comprising of 90 trees of the various fruit have been tentatively selected as superior ones for propagation purposes. A brief description of fruit characters along with the gardens where these varieties are grown are also given in Table VI. The varieties have been listed and their ripening time has also been given.

TABLE VI

Showing the Varieties of Hill Fruits Tentatively Selected for Propagation Purposes

Name of the fruit	Varieties: Tentative Standard Name	Varieties: Local Name	Season	Brief Characters and Gardens where Grown
Apples	Beauty of Bath	English	Early (end of June to mid-July)	Round-flattish fruit of small size with red stripes on green colour, taste sweet to sub-acid, quality good, used as dessert apple. Grown in the garden of Agha Fazal Shah, Sunny Bank, Murree (Tr. No. 1, 2 and 5).
	Unidentified	English	Early Mid-season (Early August)	Flat small size fruit with pale-yellow to green skin colour, taste sweet and quality good, used as dessert apple. Grown in the garden of Agha Fazal Shah, Sunny Bank Murree (Tr. No. 6).
	Kashmiri Amri	Kashmiri Amri	Mid-season (end of August to Mid-Sept.)	Oblong-conical fruit of medium size with coloured flush on green surface, taste sweet, good quality dessert apple. Grown in the garden of Raja Khan Mohd. Charehan (Tr. No. 2) and S. Nur Khan Rawat (Tr. No. 11, 12).
	Delicious	Lal Amri or Delicious or Amri	Mid-season (end of August to Mid-Sept.)	Oblate-conical fruit with five prominent protuberances which is characteristic of this variety, sikn colour green to pale-yellow overspread with red-stripes and mottled with carmine splashes, taste sweet, aromatic and quality good to very good, used as dessert apple. Grown in the gardens of Raja Karam Dad, Charehan, (Tr. No. 1, 2, 3), Mali Rashan, Gulehra Gali (Tr. No. 6, 7) and S. Nur Khan, Rawat (Tr. No. 1, 5, 6, 7).
	Red Delicious (Lal Amri)	Lal Amri	Mid-season (1st fortnight of Sept.)	Conical fruit of medium to large size, skin colour golden yellow covered with deep red rays on more than two-thirds of the fruit, taste sweet aromatic, a very fine quality dessert apple. Grown in the gardens of S. Nur Khan Rawat (Tr. No. 8, 9) and M. Yunus, Aliot (Tr. No. 1, 2, 3).

Name of the fruit	Varieties: Tentative Standard Name	Varieties: Local Name	Season	Brief Characters and Gardens where grown
	Delicious	Golden Delicious	Mid-season (1st fortnight of Sept.)	Conical fruit of medium to large size, skin colour golden yellow covered with deep crimson red stripes, taste sweet with fine quality dessert apple. Grown in the garden of Raja Khan Mohd. Charehan (Tr. No. 1).
	Warner's King	Amri	Late Mid-season (end of Sept.)	Round-flattish apple of medium size, skin colour light green with faint coloured flush on sunny side, taste sweet, good quality good dessert apple. Grown in the garden of Raja Khan Mohd. Charehan (Tr. No. 4).
	Amri	Amri	Late (Early Oct.)	Oblong-oval fruit of medium to large size with yellow green skin flushed with crimson colour on one cheek, taste sweet, good quality dessert apple. Grown in the garden of Master Mohd. Ayub Gehl (Tr. No. 1). It can be kept in storage for a long time.
	Banki (Resembling with James Grieve)	Banki	Late (Mid-Oct.)	Round-flattened to oblong-conical fruit of medium to large size, skin colour pale yellow carrying light colour blush but no stripes, taste sweet, aromatic, quality good, dessert apple. Grown in the gardens of S. Nur Khan, Rawat (Tr. No. 2, 3, 4), M. Amad-ud-Din, Potha (Tr. No. 5 and 6) and Police Post, Sunny Bank (Tr. No. 1, 2).
	Golden Noble	Cooking	Late (Mid. Oct.)	Round and somewhat flattened fruit of medium to large size with clear yellow colour, taste sub-acid, quality good (for cooking). Grown in the garden of Raja Parbat Sher, Dhirkot.
	Golden Russet	English	Late (Oct.-Nov.)	Fruit small to medium in size round oblate, yellow, russetted flesh, colour creamy white crisp, sweet slightly sub-acid with marked flavour. T. S. S. 25%, dessert variety with very good keeping quality. Grown in the garden of Agha Fazal Shah, Sunny Bank, Murree (Tr. No. 8) and Raja Mohd. Ashraf, Sandian (Tr. No. 1).

Name of the fruit	Varieties: Tentative Standard Name	Varieties: Local Name	Season	Brief Characters and Gardens where grown
	Winter Greening	English	Late (Oct.-Nov.)	Fruit medium in size, round oblique, light greenish yellow with numerous small russetted dots, flesh creamy crisp, sweet with pleasing flavour, T. S. S. 16.50%, dessert variety. Grown in the garden of Agha Fazal Shah, Sunny Bank, Murree (Tr. No. 9, 10, 11).
	King Red Delicious	Lal Amri Red Delicious	Mid-season (Sept.)	Fruit medium to large, round-oblong, dark red in colour, flesh creamy, crisp, sweet with good flavour, T. S. S. 13%. Very attractive dessert variety. Grown in the garden of Nazar Mohd. Khaksar, Sandian (Tr. No. 1, 2, 3, 4 & 5).
	Red Delicious	Lal Amri	Mid-season (Sept.)	Fruit medium to large, round-oblong, red in colour flesh creamy, crisp. sweet with pleasing flavour, T. S. S. 15%, attractive dessert variety, Grown in the garden of Raja Taj Mohd. Khan, Rawat (Tr. No. 1, 2 & 3).
	Delicious	Kashmiri Amri	Mid-season (Sept.)	Fruit large in size, oblong, light yellow, with numerous red streaks, flesh white with creamy tinge, crisp, sweet, flavour not marked, T. S. S. 13%. A very attractive variety with very good keeping quality. Grown in the garden of Raja Taj Mohd. Khan, Rawat (Tr. No. 4, 5 & 6).
	(Unidentified)	Saharni	Early (July)	Fruit small in size, round oblong, red with abundant red streaks especially on the upper side, flesh light creamy, crisp, sweet with good flavour, T. S. S. 12%. A very good early variety which ripens during early July with good keeping quality and attractive colour. Grown in the garden of Raja Karam Dad, Sui (Tr. No. 1, 2, 3, 4, 5 & 6).
Pears	Bartlett	Baggu-Gosha	Mid-season (August)	Oblong-pyriform fruit of medium size with light-yellow colour, taste very sweet, fine flavoured, quality best. Grown in the gardens in Sunny Bank, Charehan, Bhamrot and some other gardens (Total Tr. 6).

Name of the fruit	Varieties: Tentative Standard Name	Varieties: Local Name	Season	Brief Characters and Gardens where grown
	Comice	Nashpati	Mid-season (August)	Round-pyriform fruit of medium to large size with yellow colour covered by dull to crimson blush, taste very sweet, aromatic, quality very good. Grown in the garden of Raja Khair Mohd. of Bhamrot (Tr. No. 2).
Plums	Green Gage	English Plum	Mid-season Mid-July)	Roundish plum of small to medium size, skin, colour dark red, taste sweet to very sweet, fine quality. Grown in the garden of Agha Fazal Shah, Sunny Bank (Tr. No. 5 to 7).
	Alu Bukhara	Alu Bukhara	Late Mid-season (last week of July).	Oblong-oval cordate, tapering towards apex, medium to large size, skin colour yellow to pink, taste sweet, good quality dessert plum. Grown in the garden of Raja Khair Mohd., Bhamrot (Tr. No. 3).
	Wickson	Alu Bukhara	Late (early August or end of July).	Round obliquely cordate, size medium to large, skin colour red to reddish pink, taste sweet, pleasant, good quality dessert plum. Grown in the gardens of Makhan Khan, Sunny Bank (Tr. No. 1) and Raja Karam Dad, Charehan (Tr. No. 2).
	Victoria	English Plum	Late (mid-August)	Oval-oblong with distinct neck, size medium to large, skin colour reddish purple overspread with fine purple bloom, taste sweet aromatic good quality, dessert plum. Grown in the garden of Agha Fazal Shah, Sunny Bank, Murree (Tr. No. 8).
	Damson	English	Late (Aug.-Sept.)	Roundish, small in size, deep blue to black in colour, flesh colour yellowish, sweet, very juicy melting with good flavour, T. S. S. 20%. Grown in the garden of Agha Fazal Shah, Sunny Bank, Murree (Tr. No. 10).

Name of the fruit	Varieties: Tentative Standard Name	Varieties: Local Name	Season	Brief Characters and Gardens where grown
	Transparent Gage	English	Late (Aug.-Sept).	Round to round with flat ends, medium in size, light yellow in colour, flesh yellowish, firm, sweet. A good variety with very good keeping quality. Grown in the garden of Agha Fazal Shah, Sunny Bank, Murree (Tr. 11 & 12).
	President	English	Late (Aug.-Sept.)	Oblong oval, large in size purple blue in colour, flesh light yellow sweet, T. S. S. 14%. A very attractive variety. Grown in the garden of Agha Fazal Shah, Sunny Bank, Murree (Tr. No. 13 & 14).
Apricots	White No. 1	Sufaid	Mid-season (Mid-June)	Oblate apricot of medium to large size, skin colour pale-yellow, taste sweet, quality good. Grown in the gardens of Zurab Khan, Charrapani (Tr. No. 1 to 4) and Samli Nursery (Tr. No. 1).
	Unidentified	Red	Mid-season (Mid-June)	Round to slightly oblate large size skin colour reddish to pale, taste sweet, fine quality. Grown in the gardens of Rahim Dad, Sandian (Tr. No. 1) and Sadiq Bukhari, Ghora Gali (Tr. No. 1).
	Nuri	Sufaid	Late (end of July)	Round apricot of medium size, skin colour pale yellow to light green, taste very sweet, quality very good, Grown in the garden of S. Nur Khan, Rawat (Tr. No. 1 to 3).
	Unidentified	Red	Late (June)	Roundish-ovate, medium in size, orange in colour, flesh also orange in colour, sweet, fine grained, T. S. S. 14.5%. A late attractive variety. Grown in the garden of Khan Mohd. Aslam Khan, Sunny Bank, Murree (Tr. No. 1).
Peaches	Elberta	Peach	Late (end of July)	Oblong-round-oval fruit of large size, skin colour greenish yellow with red splashes, taste sweet to sub-acid, quality good for dessert and canning. Grown in the garden of Raja Khair Mohd., Bhamrot (Tr. No. 2) and Azad Khan Sandian (Tr. No. 1).

Name of the fruit	Varieties: Tentative Standard Name	Varieties: Local Name	Season	Brief Characters and Gardens where grown.
Cherries	Unidentified	Cherry	Mid-season (Early June)	Cordate fruit of medium to large size, skin colour purple red, taste sweet, quality good. Grown in the garden of Raja Karam Dad, Charehan (Tr. No. 5 & 6).
Walnuts	Kaghzi No. 1	Kaghzi	(September)	Roundish to oblong-oblate fruit of medium to large size, shell colcur amber, taste sweet, very good quality. Grown in the garden of Azad Khan, Sandian (Tr. No. 1).
	Kaghzi No. 2	Kaghzi	(September)	Oblong-oval fruit of large size, shell light amber, taste sweet, gocd quality. Grown in the garden of Azad Khan, Sandian (Tr. No. 2).

The following specifications of early, mid and late seasons have been used in case of various fruits :—

Kind of Fruit	Early	Mid	Late
Apples	June-July	August-September	October-November.
Pears	July	August	September.
Plums	May-June	July	August.
Apricots	May	1st half of June	2nd half of June.
Peaches	June	1st half of July	2nd half of July.
Cherries	May	Early June	Late June.

5. Survey of Murree Hills for Growing Apples

With a view to convert Murree Hills into apple-region of the province survey of all those places which were above 4,000 ft. altitude was undertaken in this area for determining the future scope and possibilities of growing apples in these Hills. The survey was carried out in July-August, 1954.

The survey revealed that out of the total fruit area of 350 acres, 250 acres were under apples. The total number of bearing and non-bearing trees was 10,675 and 36,155 respectively. This showed that even at that time apples dominated the fruit industry of Murree Hills. But, on the other hand, the data also showed that the acreage under apple was hardly one per cent of the total cultivated area of about 26,000 acres (the area above 4,000 ft. altitude). It was further revealed that about 9,300 acres, *i.e.*, 35% of the total cultivated area, can further be brought under apples.

6. Classification and Identification of Existing Fruit Varieties

Almost all cultivated varieties of deciduous fruits being grown, at present, in the Murree area are exotic. They were either imported from Kashmir Valley or other

foreign places like England and U.S.A. None of these varieties have retained their original names and in many cases they are now called either after the colour of their skin, or the use to which they are put or the place of importation. Thus there are apple varieties known as Amri, Kulu, Kashmiri or English. In pears some are called as Baggu-gosha, others as Nakh or "Wallaite". Similarly many plum varieties are known as "Alu-Bukhara" or "Alucha" while in apricot some are said to be red, others white varieties.

In view of the great importance of standard names in the propagation of fruit varieties, the work on their description and identification was also initiated along with other activities of the Scheme. The procedure adopted was either to identify the varieties from the standard literature on this subject or in cases where identification was not possible, by giving them separate appropriate names.

In connection with this work a total of 176 samples of the following fruits were brought under study during the period under report:—

Kind of Fruit		*Samples described*
Apples	...	73
Pears	...	16
Plums	...	30
Apricots	...	19
Peaches	...	2
Walnuts	...	2
Olives	...	3
Cherries	...	20
Loquats	...	11
Total	...	176

In several cases the same variety either collected from various sources or repeated twice or thrice was treated as separate sample and thus was given separate sample number to avoid confusion in the final analysis of the data. It, therefore, implies that the above list does not show the number of varieties actually grown at this time in this area.

From the description work carried out up till 30th June, 1961, about 33 varieties, that is, 16 of apples, 9 of plums, 2 each of pears, apricots and walnuts and one each of peach and cherry have either been identified or given tentative standard names.

7. Introduction and Trial of New Fruits

Before the start of this Scheme, pome and stone fruits were being cultivated in the Murree Hills in addition to loquats and walnuts. Since 1952, that is, when this Scheme was brought into operation, the following fruits have been successfully introduced in this region:

(*i*) Strawberries.
(*ii*) Avocado.
(*iii*) Persimmon.
(*iv*) Cape Goose Berry.
(*v*) Citrus.
  (*a*) Malta.
  (*b*) Sangtra.

The performance of the above-mentioned fruits at the lower elevations have given very encouraging results and in the next few years people are going to take up planting of these fruits especially Malta and Sangtra. Growing of Malta and Sangtra has the additional advantage as the fruit is of excellent quality and excels that which is produced in the plains. Fruit also ripens about a month and a half late and thus its availability is prolonged substantially.

With the shifting of capital to Islamabad strawberry is another fruit which has vast scope as it is one of the most paying fruit. There is great demand for this fruit especially for making Jam by the preservation industry of the province. Numerous enquiries are received every year for the supply of fruit. Similarly Cape Goose Berry is in demand for making Jam. Experiments conducted at Charrapani with the cultivation of this fruit indicate that lower hills are ideally suited for this fruit.

8. Research Work

In the first few years more attention was paid to establishing the Research Sub-Stations to lay foundation for conducting research on proper lines and thus research

was confined to problems of practical nature and propagation type such as:—

(*i*) Germination Trials on Rootstock seeds of Crab apple, Peach and Walnut,
(*ii*) Top-working trials on "Batangi" (wild pear) and "Hari" (wild apricot).
(*iii*) Cultivation trials on strawberries.
(*iv*) Varietal Trials on Strawberries at Charrapani.
(*v*) Varietal Trials on Strawberries at Sialkot.

As varieties of different fruits are coming into bearing at the sub-stations more research work is being included in the Annual programme of the Scheme. This work is likely to increase further in the years to come. The research work so far conducted and the research work which is in hand is briefly reported below:—

A. RESEARCH WORK SO FAR CONDUCTED

I. Germination Trials on Rootstock Seeds of Crab Apple, Peach and Walnut

These trials were initiated at Hill Fruit Research Sub-Station, Sunny Bank, Murree in the year 1954 and concluded in the year 1958, with the object of determining the methods of obtaining maximum germination of stock seeds of deciduous fruits. The problem has been attacked from various aspects, that is, sowing the seeds direct in the field at various depths and on different dates, sowing after stratification at different dates, sowing of peach seed with and without seed coat and determining the correlation of the size of seed to the size of seedlings in case of peach and walnut only.

No conclusive results have been obtained mainly due to uncertain weather conditions prevailing during the period of sowings and germination of seeds. Sometimes there were no rains and sometimes there were heavy rains or snowfall. In some cases sowing dates were missed due to early snowfall as it was not possible to effect sowings. However, data collected have given some useful indications with regard to the time of sowing stock seeds under trial which are reported here as under:—

(*i*) Sowing of seeds directly in the field has given better germination than sowing after stratification in case of crab-apple and peach. In case of walnuts also the direct sowing has proved better except during the first year of the experiment when both these methods behaved alike.

(*ii*) Regarding time of sowing the period from Mid-November to Mid-December has given better germination than sowing at later dates. The results in respect of depths of sowing are not clear. The depths used were equal, twice or thrice the diameter of the seed. Earlier sowings took more time for germination.

(*iii*) In stratification trials the seeds of crab apple, peach and walnut stratified in soil have given better germination on the whole than in the sand. Snow as media for stratification has proved a failure.

With regard to the time of stratification, though early December has been noticed to be better but the results are not very clear.

(*iv*) In finding out the effect of seed-coat (shell) on germination of peach seed the data have indicated that sowing with shell intact would yield better germination as compared to those in which the shell is partly or completely removed.

(*v*) The correlation of size of the seed to the size of seedlings (6 months old) could not be established. It was, however, interesting to note that the germination percentage increased with decrease in size. In case of walnut results of second year were not clear.

II. Trials on Top-working of "Batangi" (wild pear) and "Hari" (wild apricot)

There are thousands of "Batangi" (wild pear) and "Hari" (wild apricot) trees growing wild in Murree Hills which can be converted into superior varieties by top-working. Trials were, therefore, initiated in spring 1955 to determine the suitable methods of re-working them and proper sealing materials for use in grafting.

The methods compared were cleft-grafting and bark-grafting while the graft-sealing materials employed were indigenous material (burlap pieces mixed with mud) and standard grafting wax and East Malling Wax. In the years 1957 and 1958, however, East Malling Wax could not be

used as it was not available. The results of the experiment are briefly given below:—

(*i*) Bark grafting has proved to be a better method than the cleft grafting. However both the methods can be employed with advantage in case of "Batangi".

(*ii*) Standard grafting wax is a better sealing material than the indigenous material.

(*iii*) Top-working as a method of converting wild or inferior trees into superior varieties is more successful in case of "Batangi" than "Hari".

As the method of top-working mentioned above gave very little percentage of success this method could not be employed on a large scale in case of "Hari". In the year 1959 this method was modified in order to evolve a better technique for the top-working of "Hari". The plants selected for the purpose were headed back before the start of growth and then limited number of shoots were allowed to grow. These shoots were then budded by the common T-budding method during the beginning of July, mid of July, beginning of August and mid of August. This modified experiment has already been conducted for the last two years and the following tentative conclusions can be drawn:—

(*i*) T-budding as a method of top-working of "Hari" is a better method than cleft-grafting or bark-grafting.

(*ii*) During the first year mid-July proved to be the best time as it gave as much as 80 % success but during the second year, July budding proved an utter failure due to continuous rains. However, mid-August gave the highest success of 62.5%.

III. Cultivation trials on strawberries

The strawberry fruit was first introduced in the Murree hills in the year 1951-52. In order to standardise the method of cultivation of this fruit, trial was started at the Hill Fruit Research Sub-Station, Charrapani in October, 1954. Planting on flat, with and without runners were compared with planting on ridges, with and without runners. The results obtained are briefly reported below:—

(*i*) Planting on ridges proved to be a far superior method than on flat. Average yield obtained was 10.15 maunds and 6.32 maunds per acre respectively.

(*ii*) Strawberry fruit being perishable was badly damaged by irrigation water when sown on flat. It was also spoiled by dirt. The fruit in case of crop planted on ridges was clean and fine.

(*iii*) De-runnering is a very good practice as it increases the yield of the fruit to a great extent. In case of de-runnering the fruit also ripened a fortnight earlier.

IV. Varietal Trials on Strawberries at Charrapani

This experiment was first initiated at the Hill Fruit Research Sub-Station, Sunny Bank, Murree in the year 1953. The unfavourable weather conditions which usually prevail at the time of fruiting at Murree proved a great handicap in the successful cultivation of this fruit. Plants also did not attain proper size due to poor condition of growth. The trials were therefore, shifted to Charrapani during the year 1956. The five varieties included in this experiment were Samli, Peshawari, Missionary, Blakemore and Klondyke. The data were collected on spread, height of plants, yield and total soluble solids and acidity of fruit to compare vigour, fruiting and quality of different varieties.

From the data taken following conclusions can be drawn:—

(*i*) Peshawari variety proved most vigorus followed by Klondyke and Samli.

(*ii*) Missionary variety gave significantly highest yield followed by Klondyke.

(*iii*) All the three imported varieties have given better yield than the two local varieties included in the trial.

(*iv*) Total soluble solids were found to be maximum in Peshawari variety followed by Missionary, Blakemore, Samli and Klondyke in order of sequence.

(*v*) Percentage total soluble solids and acidity data showed that there was not much difference in the quality of fruits as the results are not statistically significant.

V. Varietal Trials on Strawberries at Sialkot

The mild climatic conditions prevailing at Sialkot appeared to be quite suitable for the cultivation of this important fruit but no systematic trials were conducted to

determine which of the varieties will do well there.. With this object in view a varietal trial was laid out at the Agricultural Station, Sialkot in the year 1957 with the five varieties, namely, Samli, Peshawari, Missionary, Blakemore and Klondyke.

The five varieties were replicated 6 times and 40 plants were included in one replication. Data were collected on volume of growth, yield and total soluble solids of the fruit. The results obtained are briefly reported below:

(*i*) Peshawari and Klondyke varieties have the maximum vigour followed by Samli. Missionary and Blakemore varieties have minimum vigour. Results are statistically significant at one and five per cent levels.

(*ii*) Klondyke variety gave the maximum yield followed by Samli and Peshawari, the difference is not, however, significant.

(*iii*) Peshawari variety has the maximum total soluble solids followed closely by Samli, Blakemore, Missionary and Klondyke in order of merit.

B. RESEARCH WORK IN HAND

I. Maturity and Quality Studies on Kinnow Mandarin

Kinnow mandarin plants were planted at the Hill Fruit Research Sub-Station, Charrapani on 23-9-55 with a view to explore the possibilities of cultivation of this important fruit in the lower Murree hills. During the year 1959 these plants bore an average of 93 fruits per plant. In order to determine the quality and proper stage of maturity of the fruit, physico-chemical analysis was carried out after fortnight intervals starting from 2nd fortnight of January up to the end of April. The data thus collected are produced below in Tables I and II.

TABLE I

Date of analysis		Average wt. of fruit	juice (Percentage)	Rag. (Percentage)	Thickness of peel	No. of seeds
21-1-60	...	3.43 oz.	48.1	37.9	0.43 Cm.	31
6-2-60	...	4.35 „	42.6	28.7	0.33 „	31
21-2-60	...	4.40 „	40.9	28.4	0.35 „	30
6-3-60	...	4.43 „	40.5	29.3	0.25 „	30
21-3-60	...	5.30 „	48.6	28.3	0.36 „	26
6-4-60	...	5.41 „	38.0	36.2	0.28 „	30
21-4-60	...	4.08 „	41.9	40.0	0.28 „	27
Total	...	31.40 „	306.0	228.8	2.24 „	205
Average	...	4.48 „	43.8	32.6	0.32 „	29.2

TABLE II

Date of analysis		T.S.S.	Acidity	T.S.S./Acid Ratio
21-1-60	...	15.3	1.03	14.8
6-2-60	...	16.1	0.94	17.0
21-2-60	...	16.2	0.86	18.6
6-3-60	...	16.4	0.80	20.5
21-3-60	...	14.0	0.78	17.8
6-4-60	...	14.0	0.77	18.2
21-4-60	...	13.6	0.73	18.2

The results of data are briefly given here as under :

(*i*) The fruit is medium in size with thin, tight, smooth and glossy skin and contains an average of 29 seeds.

(*ii*) Total soluble solids and acidity of fruit was 16.4% and 0.80% respectively on 6-3-60 and thus solid acid ratio was found to be the maximum which corresponds with the excellent taste and flavour of the fruit, thus proper stage of maturity of Kinnow fruit can safely be taken as first fortnight of March.

(*iii*) Time of ripening of Kinnow fruit at Charrapani can be taken as 15th of February to the end of March. However fruit can safely be kept on the trees up to the end of April without appreciable deterioration in quality. Thus there is great scope for the cultivation of this fruit in the lower hills as the time of ripening has advanced by more than a month and a half.

(*iv*) Quality of the fruit is much better than those produced in the plains. Total soluble solids of the fruit is 16.4% as against a maximum of about 11 per cent in the plains.

II. Maturity and Quality Studies on Valencia Late Orange

Three varieties of malta-namely Valencia late, Washington Navel and Bloodred were planted at the Hill Fruit Research Sub-station, Charrapani in order to see their performance under lower Murree Hill conditions. Valencia late variety set fruit for the first time during the year 1960, but unfortunately due to unexpected snowfall which was experienced at Charrapani most of the fruit was shed during February-March. Periodical studies which were to be taken up at regular intervals to find out the proper maturity time of the fruit and at the same time study its quality could not be possible according to the schedule. The result of the physico-chemical analysis conducted during the first week of March is given as under:

Total soluble solids	...	9.5 to 10%
Acidity	...	1.3 to 1.6%
Average weight of fruit	...	6.0 oz.
Thickness of the peel	...	0.40 to 0.55 cm.
Number of seeds per fruit		8

Although the fruit had changed its colour and appeared to be ripe yet it was lacking in flavour and had high acidity as it had not attained proper maturity.

III. Top-Working Trial on Diospyrus Lotus (*Amloke*)

There ase thousands of *Amloke* plants growing in a wild state in the Murree Hills. Although its fruit finds an easy market as it is consumed fresh as well as dried, yet it does not give proper return to the owners. This trial was, therefore, started in spring 1961 to convert these trees into superior varieties of persimmon by top-working. The methods of grafting tried were (*i*) Cleft-grafting (*ii*) Bark-grafting and sealing material used was indigenous material that is ordinary mud mixed with burlap pieces and standard grafting wax. Scion variety used was Persimmon seedless (Mardan). Amloke trees for the purpose were selected at Charrapani, Samli and Sunny Bank.

The observations made so far show that not a single graft is successful. The main cause for the total failure appears to be that there was difference of considerable period in the sprouting of scion wood and flow of sap in the *Amloke* plants. Bud-wood was taken from the persimmon plants, planted at the Hill Fruit Research Sub-Station, Charrapani.

IV. Distinguishing Characters of Fruit of Different Varieties Planted at the Hill Fruit Research Sub-stations, Murree and Charrapani

A. Hill Fruit Research Sub-Station, Sunny Bank, Murree.

Most of the plum and peach and some of the apple, pear, walnut and apricot varieties planted at this sub-station have started fruiting. The fruit of these varieties have been described in order to distinguish them from one another.

(*a*) Apple

(*i*) *Mashhadi* (*Quetta*).—Fruit medium in size, shape round oblong, colour greenish yellow with red flush ; cavity deep, wide and russetted ; stem thin and long ; basin wide and shallow ; flesh colour greenish white ; crisp with pleasing flavour ; T.S.S. 13%, quality good ; core medium to large, core line meeting, seeds 13 ; a late variety which ripens in October-November.

(*b*) **Plum**

(*i*) *Duke* (*Tarnab*)—Fruit large in size, reddish blue in colour, oblong ; cavity shallow and wide; suture continuous and conspicuous ; apex roundish ; pubescence very fine ; skin medium thick, tough, clinging with the pulp, flesh greenish yellow in colour, sour, coarse grained, leathery; T.S.S. 20% ; stone large, elongated, pitted and rough ; a late variety.

(*ii*) *No.* 1 (*Tarnab*).—Size medium to small, roundish, colour greenish yellow ; cavity deep and round ; suture indistinct, a mere line, apex roundish ; pubesence fine ; skin thin, tough and free ; flesh yellow in colour, fine grained, melting, sweet and aromatic, T.S.S. 15.9% stone medium in size, clinging to pulp, surface finely pitted. A good quality early variety, ripening towards the end of June.

(*iii*) *Samli* (*Murree*).—It resembles plum No. 1 in almost all its characters, the description of which has been given above.

(*iv*) *Methley* (*Tarnab*).—Size medium to small, roundish, colour dark red , cavity shallow and medium ; suture indistinct, a mere line ; apex roundish ; pubescence fine ; skin medium thick, tough, free to semi-free; flesh dark red, juicy, coarse grained, melting, sweet to sub-acid ; aromatic ; T.S.S. 21% ; stone medium in size, corrugated towards the stem end. A good quality mid-season variety ripening during early July.

(*v*) *No.* 7 (*Tarnab*).—Size small to medium, roundish ; colour light yellow with greenish tinge ; cavity deep and narrow ; suture indistinct, a mere line ; apex roundish ; pubescence fine ; skin medim thick, tough, free to semi-free ; flesh yellow, juicy, coarse, melting, sweet to sub-acid, T.S.S. 16.5 % ; stone medium to small, surface finely pitted.

(*vi*) *Ganzales* (*Tarnab*)—Size medium, round, red in colour ; cavity deep and narrow ; suture distinct and wide ; apex roundish ; pubescence fine ; skin medium thick, semi-free ; flesh red in colour, very juicy, sweet fine grained and aromatic ; T.S.S. 11.5% ; stone small to medium in size, surface pitted. A mid-season variety ripening during mid-July.

(*vii*) *Wickson* (*Murree*).—Size large, round conical, colour yellowish green which turns red when kept for a few days ; cavity deep, and medium in width and regular ; suture distinct and deep ; apex pointed, pubescence fine ; skin thick, tough and semi-free ; flesh yellow, firm, sweet and coarse-grained ; T.S.S. 14% ; stone small, free with rough and pitted surface. A good mid-season variety ripening during early August.

(*c*) **Apricots**

(*i*) *Nari* (*Quetta*).—Size medium, round, colour yellowish green ; cavity deep and wide ; suture deep and distinct ; apex roundish ; pubescence fine ; skin thick, tough and adhering to the pulp ; flesh yellow with light green tinge, coarse, very sweet, juicy ; T.S S. 26.5% ; stone medium in size, surface finely pitted but corrugated towards the stem end and free. A very good variety ripening by the end of June.

(*ii*) *Charmaghzi* (*Quetta*).—Size medium, shape round to round oblong, colour light yellow with greenish tinge ; cavity wide and shallow ; suture distinct and deep ; apex roundish ; pubescence fine ; skin thick, tough and adhering with the pulp ; flesh white, coarse, very sweet and juicy ; T.S.S. 24 to 27% ; stone medium to small with finely pitted surface. A very good variety ripening by the end of June.

(*d*) **Peach**

(*i*) *Golden Jubilee* (*Tarnab*).—Size medium, oblong, colour yellow with red splashes ; cavity deep, medium and regular ; suture shallow and distinct ; apex flattened ; pubescence fine, skin thick, tough and semi-free ; flesh golden in colour, medium in juice contents, coarse, firm sub-acid and aromatic ; T.S.S. 18% ; stone medium in size, pitted and corrugated and semi-clinging. A good early ripening variety (end of June).

(*ii*) *May-flower* (*Tarnab*).—Small in size, round, colour yellowish green with red splashes ; cavity wide and deep ; suture distinct ; apex roundish ; pubescence fine; skin thick ; brittle and semi-free ; stem thick and short ; flesh greenish white juicy, sweet, melting, fine grained and aromatic ; T.S.S. 19% ; stone large, corrugated, adhering with the flesh. A very good mid-season variety, ripening during second week of July.

(*iii*) 6-*A* (*Tarnab*).—Size medium to large, round, colour yellow with deep red flush ; cavity wide and shallow ; suture distinct ;

apex flattened ; pubescnce fine ; skin thick, tough and free : stem thick and short ; flesh golden with red splashes towards the stone, sweet to sub-acid, texture crisp ; T.S.S. 11% ; stone large, corrugated and free ; a good late variety.

(*iv*) *Rochester* (*Tarnab*).—Size large, round, yellow with deep red splashes ; cavity wide and shallow ; suture distinct ; apex flattened ; pubescence fine ; skin thick, tough and free ; stem thick and short ; flesh golden with red splashes towards the stone, sweet to slightly sub-acid, texture crisp ; T.S.S. 11% ; stone large, corrugated and free. A good late variety ripening during mid-August.

B. *Hill Fruit Research Sub-Station, Charrapani*

The varieties of peach, plum, loquat, persimmon, which have fruited so far have been described. Fruit characters of the varieties are given in detail here under :—

(*a*) Persimmon

Seedless (*Mardan*).—Fruit medium in size (about 5.5 ozs.), flattened square (dimensions 6.7 cms × 6.5 cms × 4.4) ; colour cernelian red, stock depressed, clayx adhering to the fruit at the stalk end, flesh colour pale yellow ; T.S.S. 26% ; flavour absent.

(*b*) Loquat

(*i*) *Loquat* (*Mardan*).—Fruit large in size ; shape round oblong ; fruit and flesh orange in colour; skin thick, brittle, separates easily from the flesh ; juicy, sour in taste, T.S.S. 15% ; seeds large, 2 to 5 in number; a late variety.

(*ii*) *Loquat* (*Lyallpur*).—Fruit medium in size, round, creamy yellow ; skin tough, brittle, separates easily from flesh; flesh creamy white, juicy and sweet ; T.S.S. 15%, seeds medium in size, 3 to 5 in number, mid-season variety.

(*iii*) *Loquat* (*Chhattar*).—Fruit small in size, roundish, deep orange in colour; skin hard, brittle, clinging with the flesh; flesh deep orange in colour, sweet with good flavour; T.S.S. 18.7% ; seeds 3 medium in size ; a late variety.

(c) Peach

(*i*) *Wiggins* (*Tarnab*).—Size large, roundish ; colour creamy with greenish tinge and red splashes ; cavity wide and deep ; suture shallow and distinct ; apex, pointed ; pubescence fine ; skin thick, tough and semi-free ; flesh creamy with greenish tinge and red splashes, fine grained, melting, sweet, aromatic ; T.S.S. 19.5% ; stone medium in size, corrugated, clinging with the flesh, a good variety.

(*ii*) *Golden Jubilee* (*Tarnab*).—Size medium to small ; round oblong, colour yellow with red splashes ; cavity, deep medium, regular; suture shallow distinct, apex flattened ; pubescence fine ; skin thick, tough, semi-free ; flesh golden, medium juice contents, coarse, firm sub-acid, aromatic; T.S.S. 18%; stone medium in size, pitted and corrugated; semi-clinging; a good variety.

(*d*) Plum

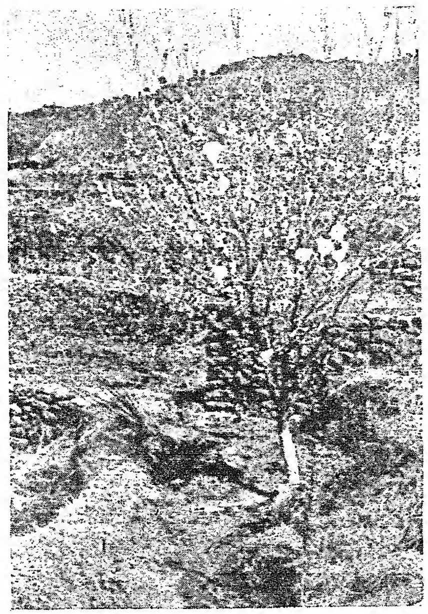
(*i*) *Ganzales* (*Tarnab*).—Fruit medium to small, roundish; colour purplish blue; cavity deep and narrow; suture indistinct, a mere line ; apex somewhat pointed; pubescence fine; skin medium thick and tough: flesh purple, juicy, sweet, fine grained; T.S.S. 11%; stone medium size and pitted; a mid season variety.

(*ii*) *Wikson* (*Tarnab*).—Fruit large in size, round conic, colour golden yellow which turns red on ripening; cavity deep, wide and acute; suture prominent; apex beaked; skin thin and brittle; pubescence fine; flesh yellow, firm, sweet, coarse grained; T.S.S. 13%; stone small in size, rough, pitted, free; a mid season variety.

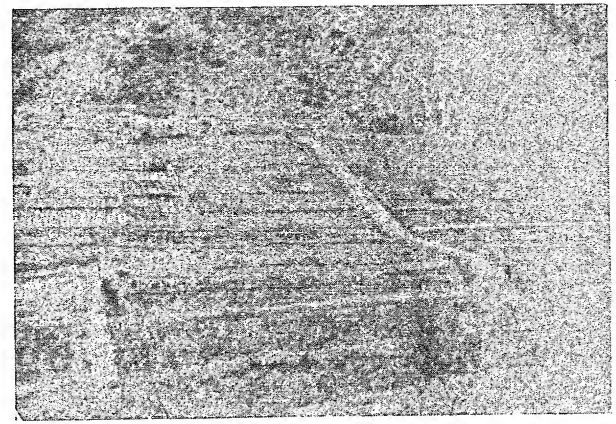
(*iii*) *Plum No.* 1 (*Tarnab*).—Fruit small in size, roundish, greenish yellow in colour; cavity deep and narrow; suture indistinct, a mere line; pubescence fine; skin thin, tough and free; flesh greenish yellow; juicy, fine grained, sweet, melting and aromatic ; stone medium, smooth, elongated, finely pitted, clinging; T.S.S. 16%; a good early variety.

(*iv*) *Plum No.* 7 (*Tarnab*).—Fruit small in size, colour light yellow with greenish tinge; cavity deep and narrow; suture indistinct, a mere line; apex roundish; pubescence fine; skin medium thick, tough, free to semi-free; flesh yellow in colour, juicy, coarse grained, melting, sweet to sub-acid, T.S.S. 15%; stone medium in size, finely pitted, clinging to the pulp; a late variety.

(*v*) *Bambrot* (*Murree*).—Small in size, red with greenish tinge, round; cavity deep and narrow; suture indistinct, a mere line;



Pollination Studies at the Hill Fruit Research Sub-Station, Charrapani



Hill Fruit Research Sub-Station Charrapani

Snow Covered Apple Plantation at the Hill Fruit Research Sub-Station Sunny Bank, Murree

pubescence fine; skin medium thick, tough adhering with the pulp; flesh yellow in colour, coarse grained, sweet, T.S.S. 14%; stone medium in size; a late variety.

(*vi*) *Robio* (*Tarnab*).—Fruit medium in size, round, reddish yellow in colour; cavity deep and wide ; suture distinct and shallow; apex pointed; skin thick, tough and adhering with pulp; flesh yellowish with red splashes, coarse grained, juicy and somewhat sour in taste; stone small in size, smooth; T.S.S. 13% a late variety.

(*vii*) *Methley* (*Tarnab*).—Fruit medium in size; roundish; colour dark red; cavity shallow and medium; suture indistinct; pubescence fine; skin medium thick, tough, free; flesh dark red, juicy, coarse grained, melting, sweet to sub-acid and aromatic. T.S.S. 15%; stone medium in size and smooth; a mid-season variety.

V. Varietal Trial on Strawberries at Rawalpindi

This experiment was laid out at the Agricultural Station, Rawalpindi with Samli, Peshawari, Missionary, Superfection and Klondyke varieties of strawberry in October, 1960. The above-mentioned five varieties were replicated six times in about 12 marlas of land. Data were collected to see the percentage of success in transplanting of different varieties which is reported hereunder :—

Samli	89.7%
Missionary	87.5%
Peshawari	86.6%
Superfection	76.3%
Klondyke	54.5%

It is thus clear that Samli variety is leading as far as success in transplanting is concerned, followed closely by Missionary and Peshawari in order of sequence. Superfection and Klondyke varieties are far inferior in this respect.

Data is also being collected on the vigour, yield and quality of fruit and will be reported in due course of time.

VI. Pruning Trials on Peach

This experiment was started at the Hill Fruit Research Sub-Station, Charrapani in February, 1961 to see the effect of different intensities of pruning on the yield, quality and size of peach fruit.

Following intensities of pruning have been performed to compare them with control *i.e.* no pruning.

(*i*) Severe *i.e.* pruning of $\frac{3}{4}$ portion of new growth.

(*ii*) Mediun *i.e.* pruning $\frac{1}{2}$ portion of new growth.

(*iii*) Light *i.e.* pruning $\frac{1}{3}$ portion of new growth.

In addition to the above mentioned pruning, plants were also thinned out from within and the branches which were diseased, dried or crossing each other were also removed from all the treatments in a uniform way.

The four varieties included in this experiment are:—

(*i*) Elberta. (*ii*) Early Elberta.
(*iii*) Rochester. (*iv*) Golden Jubilee.

The observations taken on the time of fruit setting show that pruning has no remarkable effect on the time of fruit set. Data is being collected on the yield and quality of fruit which will be reported in due course.

VII. Propagation Trials on Apples

Object of this experiment is to find out an easy and economical method of propagation of apples. This experiment has been laid out at the Hill Fruit Research Sub-station, Charrapani this year (1961). The details of the experiments are given below:—

METHODS OF GRAFTING AND BUDDING

(*a*) **Cleft**

(*i*) Directly in the field.

(*ii*) Grafting outside and then planting them immediately in the field after grafting.

(*iii*) Grafting outside and storing the grafted plants in moist sand for one week before planting in the field.

(*b*) **Whip and Tongue**

(*i*) Directly in the field.

(*ii*) Grafting outside and then planting them immediately in the field after grafting.

(*iii*) Grafting outside and storing the grafted plants in moist sand for one week before planting in the field.

(*c*) **T-Budding**

Time of Grafting and Budding

(*i*) Grafting—Dormant Season (February)
(*ii*) Budding—July.

For each treatment 200 uniform stock plants of crab apple were selected. The success data collected uptil the end of May, 1961 are given below:—

(*iv*) Plants grafted directly in the field have attained much better size than the ones which were grafted outside and planted immediately or planted after storing them for a week.

As T-budding has not been done, complete results could not be reported.

S. No.	Treatments	No. of stock plants grafted	No. of plants sprouted	Percentage success	Average height of grafted plants on 28-6-61
A. (*i*)	Cleft gratfting directly in the field.	200	182	91%	56.34 cm.
(*ii*)	Cleft grafted outside and then planted.	200	158	79%	12.77 ,,
(*iii*)	Cleft grafted outside and then stored in moist sand for one week before planting in the field.	200	120	60%	13.03 ,,
B. (*i*)	Whip and Tongue grafted directly in the field.	200	118	60%	25.9 ,,
(*ii*)	Whip and Tongue grafted outside and then planted immediately in the field.	200	113	59%	13.11 ,,
(*iii*)	Whip and Tongue grafted outside and then stored in moist sand for one week before planting in the field.	200	86	43%	11.93 ,,

The result of the data so far collected is briefly summarised below :—

(*i*) Cleft grafting is a better method than whip and Tongue grafting as it gives much better percentage of success. At the same time it is much easier to accomplish.

(*ii*) Grafted plants if stored in moist sand for a week effects percentage success.

(*iii*) Plants grafted directly in the field attain very good size and are more successful as compared to those grafted outside the field, storing for a week and then planting in the field.

VIII. Description of Plant, Leaves and Fruit Characters of Different Strawberry Varieties

Some time back a number of varieties, namely Klondyke, Missionary, Blakemore and Superfection of strawberry were imported from U.S.A. and planted at the two Research Sub-Stations along with Samli and Peshawari (local) varieties in order to compare their yield, vigour and fruiting. Results of these experiments have been reported above in this report. Work on describing the characters of different varieties was taken up during the year 1960 in order to distinguish them from one

another, which is reported tentatively below :—

Characters	Samli	Peshawari	Klondyke	Missionary	Blakemore	Superfection
	Varieties					
(*a*) *Plant vigour* ...	Vigorous	Vigorous	Vigorous	Medium	Weak	Medium
(*b*) *Leaves*:						
(*i*) Size ...	Large	Large	Large	Small	Small	Medium
(*ii*) Colour ...	Medium green	Dark green	Medium green	Medium green	Medium green	Dark green
(*iii*) Surface ...	Smooth and glossy	Smooth and glossy	Rugose and dull	Rugose and dull	Rugose and dull	Rugose and dull
(*iv*) Petiole ...	Thick	Thick	Medium	Slender	Medium	Thick
(*c*) *Fruit*:						
(*i*) Apex ...	Obtuse to flat	Acute	Obtuse	Pointed	Conical	Round
(*ii*) Surface colour	Light pink to pink	Light pink to pink	Red	Greeinsh pink	Pink	Pink
(*iii*) Calyx ...	Green	Green to greenish brown	Coloured	Coloured	Green	Green
(*iv*) Adherence to fruit	Medium	Slight	Strong	Light	Strong	Strong
(*v*) Flesh colour ...	White to pinkish	White to pinkish	Red	Red	Red	Red
(*vi*) Taste ...	Sweet to sub-acid	Sweet to sub-acid	Sub-acid	Sub-acid	Sweet to sub-acid	Sub-acid
(*vii*) Flavour ...	Aromatic	Aromatic	Good	Good	Good	Fair
(*d*) *Seeds* ...	Medium	Medium	Numerous raised	Numerous raised	Numerous raised	Numerous raised
(*e*) *Season* ...	Late	Late	Early	Early	Early	Early

IX. Propagation Studies on Walnuts:—

Propagation of Walnuts is a very difficult task as the percentage of success achieved by patch budding which is the most common method followed for raising plants of superior varieties is very low. In order to standardise some method for the propagation of this fruit an experiment has been laid out at the Hill Fruit Research Sub-Station, Charrapani.

Following methods are being tried:

(*i*) Patch budding.
(*ii*) Cleft grafting.
(*iii*) Whip and tongue grafting.

Time of Grafting and Budding

(*i*) Dormant season for cleft and whip and tongue grafting.

(*ii*) Late Summer (September) for patch budding.

Cleft and whip and tongue grafting of the plants selected for the purpose were performed in the end of February (1961). At this stage it is not possible to report the results as patch budding is still to be conducted.

X. Pollination Studies on Apples, Pears and Plums.

This experiment has been initiated this year (1961) at the Hill Fruit Research Sub-Station, Murree in order to study the pollination behaviour of different varieties of apples, pears and plums.

(*i*) **Apples.**—Three varieties of apples *viz.,* Amri, Golden Delicious and Red Delicious had blossomed and thus these studies were restricted to these varieties only. 50 flowers were covered with butter paper bags on each of the 3 trees of Amri and Golden Delicious and 2 trees each of Red Delicious variety. Same number of flowers were left uncovered but labelled for comparison sake. As soon as the fruit was set bags were removed and the number of fruits set were counted and percentage worked out. The data colleeted are presented in the Table below :

Table showing pollination behaviour of different varieties.

Variety	Date of Blossoming	*Number of blossoms* Covered	Uncovered	*Percentage Fruit Set* Covered	Uncovered	Conclusions
Amri	16-4-61	150	150	Nil	44.7	Self unfruitful
Golden Delicious	18-4-61	150	150	Nil	0.66	All the flowers were shed due to very low temperature, therefore, results not given
Red Delicious	23-4-61	100	100	Nil	7.00	Self unfruitful

As is evident from the above Table Amri and Red Delicious varieties are self unfruitful. In case of Golden Delicious no fruit, was set as all the flowers had dropped due to very low temperature on account of Aails.

(*ii*) **Pears.**—Pear varieties included in these studies were Kieffer, Leconte, Bartlet (Quetta), Louise Bonde Jersey and William's Bonchretien. It had not been possible to cover equal number of blossoms on all the varieties as all the plants did not blossom to full extent. The data collected are given in the Table below :—

Table showing pollination behaviour of different varieties of pear

Variety	Date of Blossoming	*Number of Blossoms* Covered	Uncovered	*Percentage Fruit Set* Covered	Uncovered	Conclusions
Kieffer	10-4-61	150	150	14.9	58.7	Partially self fruitful
Leconte	15-4-61	150	150	31.3	78.0	Partially self fruitful
Bartlet (Quetta)	17-4-61	50	50	8.0	14.0	Bags torn by hail, therefore results not given
Louise Bonde Jersey	18-4-61	40	40	6.0	20.0	Bags torn by hail, therefore, results not given
William's Boncheritien	18-4-61	100	100	1.0	7.0	Self unfruitful

The observations recorded above indicate that the varieties Kieffer and Leconte are partially self fruitful and William's Boncheritien self unfruitful. In case of Bartlet and Louise Bonde Jersey as most of the bags were torn by hails before the fruit had set and thus the results are doubtful.

(*iii*) **Plums.**—In case of plums, 8 varieties namely Wickson, Methley, Plum No. 1., Plum No. 3, Fazal-e-Manani, Robio, Plum No. 7, and Ganzeles were selected for these studies. Same procedure was adopted as has been reported in the case of apples and pears. Unluckily hails and excessive rains at the time of fruit setting sore off most of the bags. Although such bags were replaced there and then as toon as the rain stopped but still in some acess results are doubtful. The data collected are produced below :

Table showing pollination behaviour of different plum varieties

Variety	Date of Blossoming	*Number of Blossoms* Covered	Uncovered	*Percentage of Fruit Set* Covered	Uncovered	Conclusions
Wickson	15-3-61	150	150	5.3	66.7	Self unfruitful
Methley	15-3-61	100	100	10.5	58.0	Bags torn by hails (doubtful)
Plum No. 1	19-3-61	100	100	46.0	77.0	Bags torn by hails (doubtful)
Plum No. 3	19-3-61	100	100	36.0	49.0	Bags torn by hails (doubtful)
Fazal-e-Manani	20-3-61	100	100	15.0	34.0	Partially Self fruitful
Robio	25-3-61	100	100	2.0	36.0	Self unfruitful
Plum No. 7	29-3-61	100	100	24.0	58.0	Partially self fruitful
Ganzeles	30-3-61	100	100	1.0	8.0	Self unfruitful

From the above table it is clear that the varieties Fazal-e-Manani and Plum No. 7 can be grouped together as partially self fruitful and the varieties Wickson, Robio and Ganzeles as self unfruitful. The results in case of the remaining varieties are doubtful as the bags were torn off by rains and hails.

GRAPE-VINE HYBRIDIZATION

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THE grape is a sub-tropical fruit which according to authentic records originated from Armenia, a district near about the Caspian Sea in Russia. It seems to have been introduced into Indo-Pak subcontinent by Muslim rulers about 1300 A.D.

The grape requires a hot, dry, rainless summer and a cool rainy winter. Two distinct seasons of summer and winter as found in Quetta and Chaman in Baluchistan are ideal for grapes. Rains in summer are very injurious, as the excessive moisture in the atmosphere coinciding with the cropping season causes fungus diseases on the leaves and fruit.

The grape is a very delicious fruit and contains large quantities of sugar and useful minerals. Grape juice is a thirst-quencher, a stimulant to the kidneys and a laxative.

There are three classes of grapes. Grapes that are good for eating fresh are called table grapes and those which are dried, though quite good for eating as fresh grapes, are called "raisins". There are still others which are called juice and wine grapes. These are used for manufacturing wine and juices.

Although the grape is not cultivated on a commercial scale in any part of the old Punjab, yet it seems to have taken a fancy with the growers inasmuch as a few plants may be seen in any locality. It may be partly due to unsuitable climate and partly to the lack of varieties suitable for our conditions. It was particularly with the latter viewpoint that large number of varieties from various parts of the world including U.S.A., Russia, Australia etc., were imported for acclimatization and subsequent improvement by hybridization. Unfortunately, the varieties imported from Russia did not survive.

The varieties imported were planted in Experimental Garden, Lyallpur. These got mixed up, with the result that at the time of fruiting an admixture of several distinct varieties was noticed in rows of most of them. This presented difficulties in the matter of recording yields and labelling them for future breeding work. It was thus felt imperative that the varieties be isolated for proper nomenclature through systematic description. This naturally necessitated the carrying out of detailed investigations into their morphological characters. In planning the investigational work reported herein, the treatise on viticulture by Perold (1927) was found to be very helpful.

The investigational work was carried out over a number of years. The descriptive data so collected, have been properly arranged to facilitate easy reference. The relative importance of various parts of a vine responsible for giving the varieties their distinguishing characters is discussed for the identification of various varieties.

METHOD EMPLOYED

A study of the following parts of the vine was made in each case on the lines set forth as under :—

(1) *General vigour* : According to the general appearance and thickness of trunk the varieties were classed as vigorous medium and poor.

(2) *Unfolding leaves* : The colour and pubescence of unfolding leaves was recorded.

(3) *Growing shoots* : The degree of pubescence was noticed on growing shoots during April-May and the shoots were graded as follows :—

(*a*) *Glabrous* : When there is hardly any pubescence.

(*b*) *Cobwebby* : When the pubescence extends to the first five nodes reckoned from the tip of the shoot.

(*c*) *Downy or fairly pubescent* : When the pubescence extends over the first ten nodes.

(*d*) *Woolly or strongly pubescent*: When the pubescence extends over more than ten internodes.

(4) *Full grown leaves* : Such observations as leaf shape (Figs. 1 and 2), pubescence, dentition, pubescence and colour of leaf nerves, colour and pubescence of petiole, etc. were made separately for each variety.

(5) *One year old wood (canes)* : The properties of the ripened wood were noted after the leaves had dropped in order to see how far they could help in distinguishing varieties. Their study consists of describing the colour shades and pubescence if persisting. To study the length of internodes ten shoots were taken in case of each variety, which has been described as short, medium long and long as under :—

Short : Average length of internodes up to 3 cms.

Medium long : Average length of internode from 3.1 to 4.5 cms.

(6) *Flowers :* The varieties were described as having perfect or imperfect flowers, depending upon the presence or absence of essential parts.

(7) *Bunches and berries* : Detailed notes on shape, size and compactness of bunches ; size and toughness of peduncle, size and condition of pedicel ; shape of berries, colour and condition of skin, condition and taste of pulp, number, colour and shape of seeds, etc., for each variety were recorded.

The description of some important grape varieties on the lines set out above is arranged as follows in an alphabetical order.

AGAWAM

Vines.—Of medium vigour.

Shoots.—Medium-thick, medium long, rough ; colour red in streaks on green ; pubescence strongly woolly ; internodes medium-long tendrils medium long, pubescent, trifid, discontinuous ; tips of growing shoots brownish green ; young leaves appear white due to dense pubescence on both surfaces, margin green.

Canes.—Angular, bark peeling off.

Leaves.—Dark green on upper but light green on lower surface, thick, rough; shape cordate ; pubescence downy on upper but felt like on lower surface ; leaf entire, petiolar sinus slightly open below ; teeth very broad and pointed ; terminal tooth broad, rounded and pointed ; nerves thick greenish yellow with pinkish dots, strongly pubescent, stalk very thick, yellowish green with pink shades, pubescence downy.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle short, thick and tough bunches medium, long, pyramidal, single, loose or compact even ; pedicel short, thick and warty, berries medium to large, spherical ; skin purple, thick and leathery ; berry content quite pulpy sweet with a peculiar mango flavour ; seeds dark brown, 2—4 per berry.

A light to medium cropper ; ripens during the month of July.

BEDANA

Vines.—Vigorous.

Shoots.—Thick, long, rough ; colour purple on upper but green on lower surface ; pubescence cobwebby ; internodes medium, long tendrils long, pubescent, trifid, intermittent ; tips of growing shoots pale green ; young leaves yellowish green, margin of the same colour, pubescent on both surfaces.

Canes.—Smoky angular, bark sound.

Leaves.—Green on upper but light green on lower surface, medium thick shape orbicular glabrous on both surfaces ; 5 lobed petiolar sinus closed above but slightly open in the middle, basal and lateral sinuses not well marked, V-shaped ; teeth acute and pointed ; terminal tooth acute and pointed ; nerves thin, light pink but red near their point of origin on the upper

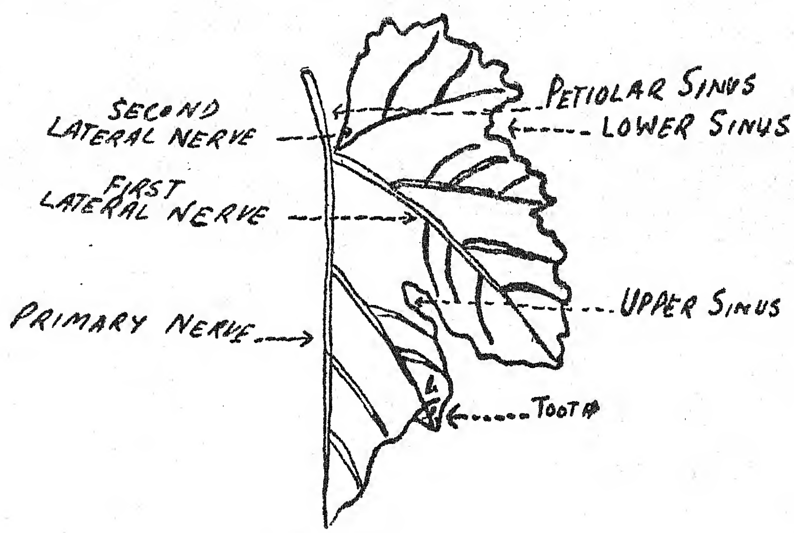

FIG I

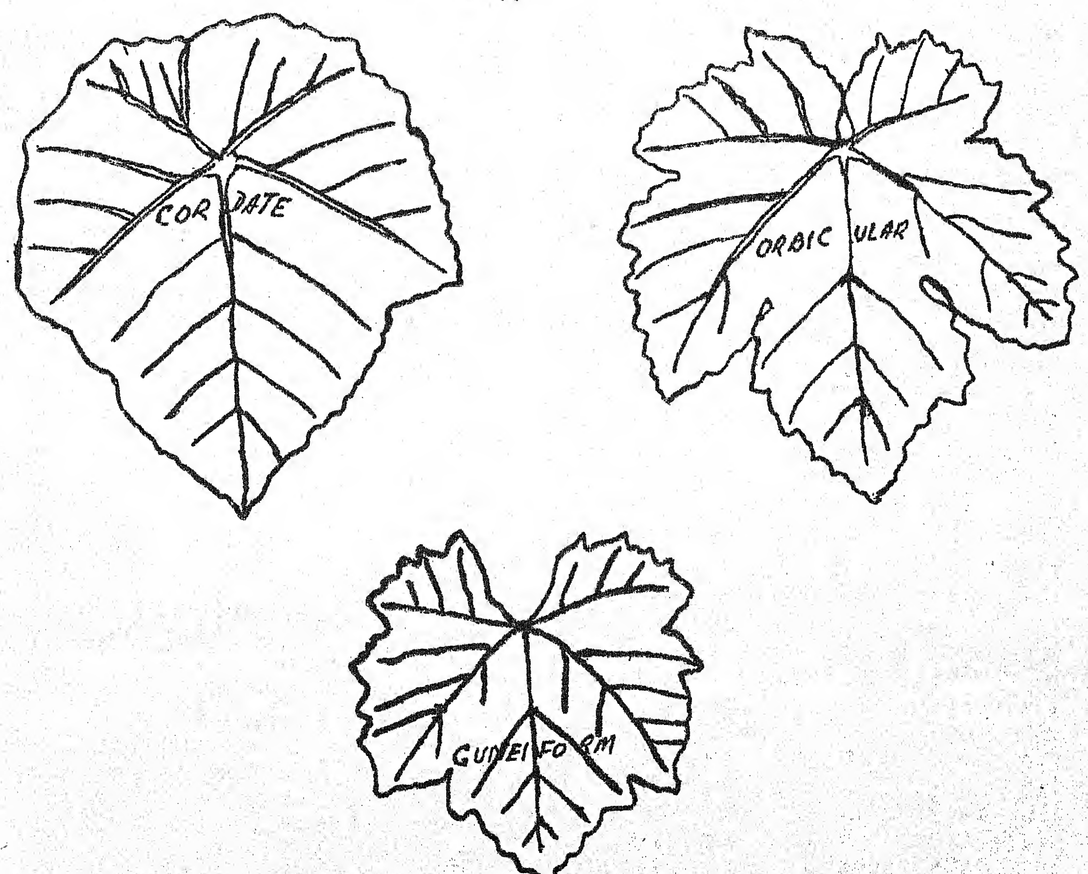

FIG II DIFFERENT FORMS OF LEAF

surface, slightly pubescent ; stalk short thin, green with purple streaks, glabrous on both surfaces.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle long, thick and brittle ; bunches large-sized, long, pyramidal, single, compact ; ripening fairly even ; pedicel medium-long, thin and warty ; berries small sized, oval ; skin greenish yellow, medium-thick and cracking ; berry content a bit firm, sweet and of good flavour, seedless.

A medium cropper ; ripens from the middle of June to middle of July.

BLACK PRINCE

Vines.—Vigorous.

Shoots.—Long, thick and rough ; colour mostly green with dark purple bands on nodes and streaks on internodes ; pubescent downy ; internodes short ; tendrils medium to long, bi- or trifid pubescent and intermittent ; tips of growing shoots yellowish green, pubescent ; unfolding leaves, yellowish green with pink margins, pubescence on both surfaces.

Canes.—Smoky on purple background, round.

Leaves.—Dark green on upper but light on lower surface, thick and rough ; shape orbicular ; pubescence downy on upper but felt-like on lower surface ; 3-lobed, petiolar sinus upon, but lateral sinuses not very well marked ; teeth in two series, small ones regularly alternating wi.h large, broad and pointed ones ; terminal tooth long, narrow and pointed ; leaf nerves medium-thick, pinkish yellow and pubescent ; leaf stalk short medium thick, yellowish green with purple shades and pubescent.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle medium-thick, medium long, and tough with or without a lateral bunch ; bunches medium or large-sized, long, pyramidal, single or divided, loose or compact ; ripening even ; pedicel thin, long and warty ; berries large or medium-sized, shape spherical, skin dark purple with blue bloom, thick and leathery ; berry content separates in a mass from the skin, juicy, sweet and of distinct and good flavour ; very good quality ; seeds well developed, 1 to 3 per berry.

A medium cropper ; ripens from the middle of June to the middle of July.

BLACK PRINCE (Calif.)

Vines.—Very vigorous.

Shoots.—Thick, long, rough, dark purple shades or streaks on green ; pubescence densely woolly ; internodes medium-long ; tendrils long, tritetra or pentafid, strongly pubescent, intermittent ; tips of growing shoots brownish green, young leaves greenish white, margin red.

Canes.—Smoky on purple background round.

Leaves.—Dark green on upper but light green on lower surface, medium, slightly rough ; shape cuneiform ; pubescence downy on both surfaces ; 5-lobed, petiolar sinus cup-shaped, other sinuses closed above but open below ; teeth either narrow or broad ; terminal tooth long, narrow and broad ; nerves thin, greenish yellow with pink dots on lower surface but purple near their point of origin on upper surface, pubescent ; stalk thick, flattened, dark purple with green streaks ; slightly pubescent.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle long, thick ; bunches usually long, pyramidal, single, fairly compact, ripening fairly even ; pedicel thick, medium-long and warty berries medium or large-sized, spherical ; skin of light purple colour with blue bloom thick and leathery ; berry content firm, melting and sweet, quality good ; seed brownish green well-developed, 2—4 per berry.

A medium cropper ; ripens from the end of June to the end of July.

BLACK HAMBURG

Vines.—Vigorous.

Shoots.—Medium thick, long, rough ; colour green ; pubescence cobwebby ; internodes short ; tendrils medium-long, slightly pubescent, trifid, intermittent; tips of growing shoot yellowish green ; unfolding leaves greenish yellow, margin pink, pubescence on both surfaces.

Canes.—Purple, angular.

Leaves.—Dark green on upper surface but light green on lower one, thick and rough; shape cuneiform; pubescence downy on upper but felt-like on lower surfaces; 5-lobed, petiolar sinus well marked, cup-shaped, others well marked, cup-shaped, others well marked, U-shaped; teeth large, narrow and pointed; terminal tooth very narrow, long and pointed; nerves thick, greenish yellow with pink dots, strongly pubescent; stalk medium-thick, medium long, dark purple shades mixed with yellowish green, almost glabrous.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle medium-long, medium-thick, tough; bunches medium or large-sized, long, pyramidal single usually loose; ripening even; pedicel thin, long and warty; berries medium or large-sized spherical or short oval; skin purple or dark purple with blue bloom, thick and leathery berry content separates in a mass from the skin, more juicy than Black Prince, sweet but flavour not as distinct as in the case of Black Prince; seed dark-brown, well-developed, 1-2 per berry.

A medium to heavy cropper; ripens from the 3rd week of June to the end of July.

CHASSELAS ROSE

Vines.—Of poor vigour.

Shoots.—Thin, short to medium long, rough; greenish yellow pubescence downy; internodes short; tendrils short, trifid pubescent, intermittent; tips of growing shoots brownish green with purple colour at the nodes; unfolding leaves reddish green, margin red, pubescence woolly on both surfaces.

Canes.—Brown on one side and greyish yellow on the other, round.

Leaves.—Dark green on upper surface but light green on lower one, thick; shape orbicular; pubescence downy on lower surface but glabrous on upper one; 5-lobed, all sinuses well marked, V-shaped; teeth broad, rounded at the top and pointed; terminal tooth narrow and pointed; nerves thin, purple near their point of origin but purplish green above, pubescent; stalk short, thin, pubescent, colour yellowish green with pink shades.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle short, thin or medium thick, tough; bunches small to medium-sized, long, shouldered pyramidal, single, generally compact; ripening fairly uniform; pedicel short, medium-thick and warty; berries small to medium sized, spherical; skin pinkish green, thick, leathery berry content slightly pulpy, melting and sweet, flavour good; seed dark brown, flattened shape, generally two per berry.

A light to medium cropper; ripens from the middle of June to the 3rd week of July.

DAKH

Vines.—Very vigorous.

Shoots.—Long, thick and rough; colour dark purple, pubescence woolly; internodes medium-long, tendrils medium long strongly woolly, bifid and intermittent; tips of growing shoots brownish green, densely pubescent, unfolding leaves greenish yellow with red margins, pubescence woolly.

Canes.—Brown on one side and greyish yellow on the other, angular.

Leaves.—Dark green on the upper surface but light green below, thick and rough; shape orbicular, downy on the upper but felt-like on the lower surface; 5-lobed, petiolar sinus closed above but open below, lateral sinuses open, U-shaped, basal sinuses slightly open; teeth narrow, long and pointed, small and large ones irregularly alternating; terminal tooth very long, narrow and pointed; leaf nerves densely pubescent medium thick, purple on both sides, the intensity of colour decreasing towards the apex; leaf stalk thin, short and dark purple, pubescent downy.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle short, thick and rough; bunches medium, long pyramidal, single or divided, compact and even; pedicel short, thick and warty; berries medium sized, usually spherical skin black with blue bloom, thick and leathery; berry content juicy and fairly acidic; seeds 2-3 per berry, but sometimes more.

A very heavy bearing variety, good for juice making, ripens from the third week of June to the third week of July.

FOSTER'S SEEDLING

Vines.—Of poor to medium vigour.

Shoots.—Medium-thick, short to medium-long, rough : colour mostly green but sometimes dark purple bands on nodes and lines on internodes ; almost glabrous ; internodes medium-long ; tendrils medium-long bifid, almost glabrous, intermittent ; tips of growing shoots greenish yellow unfolding leaves pinkish green margin green, no pubescence.

Canes.—Purple, round.

Leaves.—Dark green on upper but light green on lower surface, thick and rough ; shape orbicular ; almost glabrous on both surfaces ; 3-lobed, petiolar sinus almost closed, lateral sinuses slightly marked ; teeth small of petiolar sinus almost closed, lateral sinuses slightly marked ; teeth small or large broad, rounded ; terminal tooth long and narrow ; nerves medium thick, pinkish yellow, pubescent on lower surface ; stalk long, thick slightly pubescent, colour yellowish green with purple shades.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle medium long, thick, fairly brittle ; bunches medium or large sized, long, pyramidal generally single, loose, short berries in the bunch characteristic of the variety ; ripening fairly even ; pedicel long, medium-thick warty ; berries medium-sized, spherical ; skin yellowish green, thick, leathery ; berry content firm, slightly pulpy but melting ; very sweet, excellent flavour ; one of the best varieties under trial, seed dark brown, 2—4 per berry.

A medium to heavy cropper : ripens from the middle of June to the beginning of July.

KHALILI

Vines.—Vigorous.

Shoots.—Mostly thin, long, rough ; colour dark purple in patches or streaks on yellowish green ; pubescence downy on both surfaces ; internodes medium-long ; tendrils long bifid, pubescent, intermittent ; tips of growing shoots brownish green, rubescent ; young leaves yellowish green, apmgin pink pubescent.

Canes.—Smoky on one side and brown on the other, angular, bark peeling off.

Leaves.—Dark green on upper but light green on lower surface, thin, soft ; shape cuneiform : pubescence downy on both surfaces ; 5-lobed, petiolar sinus well marked, basal sinuses less marked than lateral ones ; nerves thin, greenish yellow with pink dots, pubescent ; stalk short, thin, dark purple, slightly pubescent.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle medium long, thin, tough bunches small or medium-sized, long, pyramidal, divided, loose ripening even ; pedicel long, thin and smooth ; berries medium-sized, long-oval ; skin yellowish green with white bloom, thin and cracking ; flesh soft, weet but flavour not marked ; seed brownish yellow, 1-2 per berry.

A shy bearer, ripens in the beginning of June.

KISHMISH WHITE

Vines.—Vigorous.

Shoots.—Thick, long, rough, colour bluish red and green in patches ; pubescence cobwebby or downy ; internodes medium long ; tendrils medium long pubescent, bifid intermittent ; tips of growing shoots yellowish green ; young leaves greenish yellow, margin tinted pink ; pubescent slightly.

Canes.—Light brown but slightly smoky on one side, prominently angular.

Leaves.—Dark green on upper but light green on lower surface, thick ; shape cuneiform ; almost glabrous ; 5-lobed, all sinuses equally well marked ; teeth broad, rounded and pointed ; terminal tooth narrow and pointed ; nerves greenish yellow with pink shades, pubescent, stalk pink, short, thick slightly pubescent.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle medium-long, thick and brittle, bunches medium sized, long, shouldered, pyramidal single, compact, even ; pedicels short, thick and warty ; berries medium-sized, oval, skin greenish yellow with brown or pink shades, thin, cracking ; berry content juicy, sweet and of good flavour ; seeds well developed, brownish yellow, usually

one per berry.

A light cropper, ripens about the middle of June.

MADRASFIELD COURT

Vines.—Of very poor vigour.

Shoots.—Thin or medium-thick, very short and rough ; bluish pink shades on green ; pubescent woolly ; internodes short ; tendrils very short, bifid, woolly and intermittent ; tips of growing shoots pinkish green, densely pubescent ; unfolding leaves yellowish white, densely pubescent on both sides.

Canes.—Smoky, angular, pubesence persisting.

Leaves.—Darker green on upper than on lower surface, thick and rough ; shape orbicular ; pubescence downy on upper but felt-like on lower surface 5-lobed, petiolar sinus closed above by basal lobes but prominently open below, other sinuses less marked and V-shaped ; teeth narrow, long and pointed ; terminal tooth very narrow, long and pointed ; leaf nerves densely pubescent, red near their places of origin and of light green colour having pinkish tinge, leaf stalk short, red and woolly.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle short, thick, tough, without a lateral branch ; bunches small or medium-sized, short pyramidal, single and compact, uneven ripening is characteristic of this variety as green light purple and dark purple berries can be found in every bunch ; pedicel short, thick and warty ; berries light or dark purple, medium or large-sized ; shape oval, berry content firm, melting, very sweet and of excellent flavour ; seeds one to two per berry and of green colour.

A light cropper ; ripens about the third week of July.

MUSCAT OF ALEXANDRIA

Vines.—Of medium vigour.

Shoots.—Thick, short, rough, colour green : pubescence woolly ; internodes medium-long; tips of growing shoots green; young leaves appear white due to woolly pubescence, margin reddish ; tendrils long, pubescent, trifid or tetrafid, intermittent.

Canes.—Light brown but slightly smoky on one side, prominently angular.

Leaves.—Dark green on upper but light green on lower surface, thick and rough ; shape cuneiform ; pubescence downy on upper but felt-like on lower surface ; 5-lobed, petiolar sinus well marked but basal and lateral sinuses less marked, V-shaped ; teeth large, narrow and pointed ; terminal tooth large ; terminal tooth long, narrow and pointed, nerves thick, greenish yellow, red near their origin, strongly pubescent on both surfaces ; stalk long, thick, pink, pubescent.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle long, medium thick, fairly tough ; bunches medium to large-sized, long pyramidal, divided, loose ; ripening even ; pedicel long, thick and warty ; berries medium to large-sized, short-oval ; skin yellowish green thick cracking, berry content a bit pulpy, melting very sweet and of distinct muscat flavour ; quality good ; seed brownish ; green, 1—3 per berry.

A light to medim cropper ; ripens from the beginning to the end of July.

PANDHARI SAHEBI

Vines.—Very vigorous.

Shoots.—Thick, long and rough ; colour green or dark purple shades on green ; pubescence cobwebby ; internodes medium long ; tendrils long, trifid, pubescent, intermittent ; tips of growing shoots brownish green ; unfolding leaves greenish yellow, margin pink, pubescent.

Canes.—Brown on one side and greyish white on the other thick and vigorous.

Leaves.—Dark green on upper but light green on lower surface, thick ; shape orbicular ; slightly downy pubescence on upper surface but glabrous on lower one ; 5-lobed, petiolar sinus almost closed, lateral sinuses more marked than basal ones ; teeth large, broad, round and pointed ; terminal tooth broad, dome-shaped and pointed ; nerves thick, colour greenish yellow with pink shades or dots, pubescent ; stalk short, very thick, greenish yellow with pink shades, glabrous.

Flowers.—Practically pistillate.

Characters of the bunch.—Peduncle medium-long or short, thick and tough; bunches medim or large-sized, appearance attractive due to attractive colour of berries and compactness of bunches, long, pyramidal, single, compact; ripening uniform; pedicel long, thick and warty; berries larger-sized, long-oval; skin yellow—with lor without pink shades, thin, cracking; berry content firm, pulpy, sweet but fiavour acking seed dark brown, 1-2 per berry.

A self-sterile variety, but medium to heavy cropper when grown with self-fertile varieties; ripens from the third week of June to the third week of July.

WALTHAM CROSS

Vines.—Very vigorous.

Shoots.—Thick, long, rough, colour green; almost glabrous; internodes medium-long; tendrils medium to long, bi- or trifid, almost glabrous intermittent; tips of gowing shoots green or brownish green; young leaves yellowish green; margin red, almost glabrous.

Canes.—Smoky on one side and light brown on the other, round.

Leaves.—Dark green on upper but light green on lower surface, thick; shape cuneiform; almost glabrous on both surfaces; 5-lobed; petiolar sinus open and cup-shaped, lateral sinuses more marked than basal ones; teeth large, broad, rounded and pointed; terminal tooth long, narrow and pointed; nerves medium-thick, greenish yellow with pink shades, slightly pubescent, stalk short, medium-thick, yellowish green with pink shades; almost glabrous.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle long-thick, tough; bunches medium to large; sized, long pyramidal, single loose, ripening uniform; pedicel long medium-thick and warty; berries large, long-oval; skin yellowish green with white bloom, thick and cracking; berry content, pulpy and sweet, quality good; seeds well developed, brown coloured, 1-2 per berry.

A medium to heavy cropper; ripens from the end of July to the beginning of August.

HUSSAINI BLACK KABULI

Vines.—Very vigorous.

Shoots.—Thick, long and rough; dark purple streaks on green; pubscence woolly; internodes medium-long; tendrils medium long, pubescent; bi- or trifid, intermittent; tips of growing shoots yellowish green, pubescent; unfolding leaves yellowish green with pink margin, white shade on both surfaces due to dense pubescence, changing purple later.

Canes.—Light brown but slightly smoky on one side, prominently angular.

Leaves.—Dark green on upper but light green on lower surface thick and rough; shape cuneiform to orbicular; pubescence downy on upper but felt-like on lower surface; leaves without lobes but sometimes one or both lateral sinuses develop; teeth in two series, small ones alternating with bigger ones, narrow or broad but are generally narrow; leaf nerves medium-thick pinkish-yellow with green shades and pubescent. Second lateral nerves of purple colour on both surfaces up to the point where tertiary nerves arise; leaf-stalks thick, pubescent and have purple and green shades on them.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle medium-long, thick and tough; bunches medium-sized usually, long or short, divided fairly loose and unevn; pedicel short, thick and warty; berries large and spherical; skin black with blue bloom, thick and cracking; berry content firm, pulpy and sweet; quality fair; seed content 2-3 per berry, colour light brown.

A light to medium cropper; ripens from the end of June to the end of July.

KANDHARI

Vines.—Very vigorous.

Shoots.—Thick, long and rough; colour light green; pubescence cobwebby internodes medium-long; tendrils long, slightly pubescent, bi- or trifid, intermittent; tips of growing shoots brownish green; unfolding leaves yallowish green, pubescent, margins pink.

Canes.—Brown on one side and greyish white on the other, thick and vigorous.

Leaves.—Dark green on upper but light green on lower surface, thick ; shape orbicular ; glabrous on both surfaces ; 5-lobed basal sinuses less marked than others ; teeth large, broad and pointed ; terminal tooth narrow ; nerves thin, pubescent, yellowish green with pink shades, second laterals pinkish on both surfaces up to the point where the tertiary nerves arise ; stalk short, thick greenish yellow, glabrous.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle long, thick and tough ; bunches usually large-sized, loose or compact, pyramidal, single ; ripening fairly even ; pedicel long, thick and warty ; berries big-sized, long oval ; skin purple, thick and cracking berry content sweet ; seeds well developed, 2-3 per berry.

A medium cropper ; ripens from the middle of June to the middle of July.

MADELEINE ANGEVINE

Vines.—Of medium vigour.

Shoots.—Medium-thick, long, rough, colour purple ; pubescence woolly ; internodes short ; tendrils medium-long, bi- or trifid, woolly, intermittent ; tips of growing shoots greenish purple changing entirely purple ; young leaves yellowish green, margin tinted red, pubescence on both surfaces.

Canes.—Smoky, angular, bark peeling off.

Leaves.—Dark green on upper but light green on lower surface, thick and rough ; shape cuneiform ; pubescence felt-like on both surfaces ; 5-lobed, all sinuses well marked and U-shaped ; teeth long, narrow and pointed ; terminal tooth long, very narrow and pointed ; nerves thin, strongly woolly, colour purplish green but purple near their point of origin ; stalk short, thin, dark purple, strongly pubescent.

Flowers.—Hermaphrodite.

Characters of the bunch.—Peduncle medium-long, medium thick, tough ; bunches small to medium-sized, short, pyramidal, divided, loose, ripening even ; pedicel short, thick and warty, berries medium-sized, spherical ; skin yellowish green medium-thick and leathery ; berry content soft, melting, juicy ; berries translucent ; seed brownish yellow to light black, well developed, 2—4 per berry.

A light to medium cropper ; ripens about the first week of June and is the earliest ripening variety under trial.

Discussion of results.—A complete study of the character and properties of all the parts of important grape-vine varieties has been made and the descriptive data have been tabulated and discussed in the previous section from which it is evident that certain features of the vine are not as good as a guide for diagnostic purposes as others, *e.g.* vigour and growth, which are only of relative importance, are helpful when the varieties are grown side by side in the collection. The other feature, *e.g.* degrees of colour shades, although an excellent guide to the identification of varieties in the field, yet cannot be usefully employed in describing varieties as degree of colour is very difficult to be recorded with precision. In the identification work, therefore, only such characters are employed as would be easy of adoption and afford a more or less constant specific value under diverse conditions. These features used in their order of importance are (*a*) leaf shape and pubescence (*b*) colour of berries (*c*) shape of berries (*d*) colour of growing shoots and their pubescence, (*e*) cane characters and (*f*) some characters of peduncle, pedicel and skin.

The investigations, reported herein considered as prerequisite to breeding work, were completed and the data so collected was utilized for hybridization work. After classfication of grape-vine varieties and marking the heavy yielding and better quality grapes, the emasculation and crossing work was undertaken with a view to combine and transmit the desirable characteristics of the parents in the progeny.

The crossing work was made possible on account of the facilities provided by the Imperial Council of Agricultural Research. The work was undertaken with the following objectives:—

1. To test the value of different parents for giving the best progeny plants from economic stand-points.

2. To evolve better seedless varieties that are generally liked by people as table grapes.

3. To evolve early ripening varieties, giving better performance both regarding quality of fruits over the existing ones in our collection.

In the initial stage, 1935-36, the following crosses were made:—

Name of Cross		
Pandhari Sahebi	×	Madrasfield Court
Dakh	×	,, ,,
Pandhari Sahebi	×	Madeleine Angevine
Dakh	×	Madrasfield Court

Further crosses were made in the subsequent years and planted at the Horticultural Research Sub-station, Montgomery for studying their performance under Punjab plain conditions.

The following parents were utilized for crossing in April 1938:

Female parents:—

1. Khalili.
2. Kandhari.
3. Chaouch.
4. Bokhari.
5. Jaishi.
6. Muscat Alexandria.
7. Waltham Cross.

Male parents:—

1. Black Prince.
2. Bedana.
3. Madrasfield Court.
4. Foster's Seedling.
5. Madeleine Angevine.
6. Chasselas Rose.
7. Jona.
8. Agawam.
9. Rose.

During all this period the following crosses were made and planted in field as shown in the following table:—

Showing the particulars of F_1 seedlings of grapes under trial.

Sr. No.	Parents crossed			Year of Plantings	No. of Seedlings Planted
1	Pandhari sahebi	×	Madrasfield court	Spring 1937	27
2	Dakh	×	,,		
3	Pandhari sahebi	×	Bedana		
4	,,	×	Foster's seedling		
5	Kandhari	×	Bedana		
6	,,	×	Kandhari		
7	Dakh	×	Khalili		
8	,,	×	Madeleine angevine		
9	,,	×	Kandhari		
10	,,	×	Bedana	Spring 1939	462
12	,,	×	Dakh		
13	Foster's seedling	×	Bedana		
14	,,	×	Khalili		
15	,,	×	Black prince		
16	,,	×	Dakh		
17	,,	×	Madeleine angevine		
18	,,	×	Kandhari		

S. No.	Parents crossed			Year of Plantings	No. of Seedlings Planted
19	Foster's seedling	×	Foster's seedling		
20	Waltham cross	×	Agawam		
21	,,	×	Chasselas rose		
22	,,	×	Rose		
23	,,	×	Dakh		
24	,,	×	Foster's seedlings		
25	,,	×	Kandhari		
26	,,	×	Kishmish white		
27	,,	×	Khalili		
28	,,	×	Madrasfield court		
29	,,	×	Bedana	Spring 1940	273
30	,,	×	Black prince		
31	,,	×	Waltham cross		
32	Khalili	×	Rose		
33	,,	×	Khalili		
34	Dakh	×	Agawam		
34	,,	×	Malaga		
35	,,	×	Chasselas rose		
36	,,	×	Black prince		
37	,,	×	Rose		
38	Kandhari	×	Chasselas rose		
39	Pandhari sahebi	×	Bedana		
40	,,	×	Foster's seedling		
41	,,	×	Waltham cross		
42	,,	×	Khalili		
43	Pandhari sahebi	×	Madeleine angevine		
44	,,	×	Black prince	Spring 1939	396
45	,,	×	Dakh		
46	,,	×	Chasseles rose		
47	,,	×	Kandhari		
48	,,	×	Agawam		
49	,,	×	Kishmish white		
50	Dakh	×	Foster's seedling		

The cropping and fruit quality of F_1 seedlings

Out of 1,642 seedlings planted in the year 1943 only 467 plants fruited in 1944. The cropping and quality was noted in each case. The characters were studied on the following lines:

Bunch.—Small, large, loose, conical and tapering etc.

Berries.—Size, colour and shape etc.

Ripening.—Whether uniform or not.

Skin.—Thick or thin and astringent.

Pulp.—Whether juicy and melting or hard and spongy.

Seeds.—Their number.

Total soluble solids.—Percentages

Acidity.—Percentages.

As a result of the investigations the following crosses were considered promising:—

Sr. No.	Hybrid Seedling No.	Parentage		
1	18/22	Foster's seedling	×	Kandhari.
2	23/20	Waltham cross	×	Kishmish-white.
3	29/14	Dakh	×	Rose
4	22/11	Waltham cross	×	Rose.
5	18/19	Foster seedling	×	Kandhari.
6	19/6	,, ,,	×	,,
7	19/4	Foster's seedling	×	Kandhari.
8	13/16	,, ,,	×	Bedana.
9	13/18	,, ,,	×	,,
10	11/6	,, ,,	×	,,
11	11/10	,, ,,	×	,,
12	12/4	,, ,,	×	,,
13	37/6	Pandhari sahebi	×	Chasselas rose.
14	16/16	Foster's seedling	×	Khalili.
15	23/7	Waltham cross	×	Agawam.
16	4/15	Dakh	×	Madelein angevine.
17	18/2	Foster's seedling	×	Kandhari.
18	13/7	,, ,,	×	Bedana.
19	18/7	,, ,,	×	Kandhari.
20	5/9	Dakh	×	Madelein angevine.
21	12/12	Foster's seedling	×	Bedana.
22	18/21	,, ,,	×	Kandhari.
23	17/12	,, ,,	×	,,
24	39/34	Pandhari sahebi	×	Kandhari.
25	44/11	,, ,,	×	Foster's seedlings.
26	41/2	,, ,,	×	Bedana.
27	29/8	Khalili	×	Rose.
28	45/6	Pandhari sa hebi	×	Foster's seedlings.
29	31/10	Kandhari	×	Chasselas rose.

Out of these the first 14 varieties from Serial Nos. 1 to 14 have shown a comparatively greater promise. Their bunch berry character as studied in different years are described briefly as under:—

1. Hybrid Seedling No. 18/22.—(Foster's Seedling × Kandhari) It is a cross between Foster's seedling and Kandhari.

Bunch.—Medium, not tapering, rather loose.

Ripening.—Very uniform.

Berries.—Oval, deep purple, heavily bloomed, medium to big in size; little variation in size.

Skin.—Thin and leathery, does not dissolve in the mouth.

Pulp.—Green, very juicy and very sweet, flavour pronounced.

Seeds.—1 to 4.

Total soluble solids.—25 per cent.

General remarks.—A remarkable black earliest ripening variety of outstanding merit. Stalks of berries quite strong.

2. Hybrid Seedling No. 23/20.—A cross between Waltham Cross and Kishmish-White.

Bunch.—Small, elongated of nearly equal thickness, loose.

Berries.—Dull red, very attractive, elongated fairly big in size, size of berries not uniform.

Ripening.—Not uniform, small berries getting over-ripe whereas a few out of the big berries were still green.

Skin.—Thick and leathery.

Pulp.—Light pale green, not very juicy but pulpy, very sweet, flavour good.

Seeds.—1-2.

Total soluble solid.—29 per cent.

General remarks.—An excellent table grape of high quality, very sweet with good flavour.

3. Hybrid Seedling No. 29/14.—A cross between Dakh and Rose.

Bunch.—Medium tapering with no distinct shoulders.

Berries.—Red, glossy, very attractive, quite uniform in shape and size, round to short oval.

Ripening.—Uniform.

Skin.—Thick and leathery.

Pulp.—Light pale green, not juicy but very pulpy, very sweet and of good flavour.

Seeds.—3.

Total soluble solids.—28.4 per cent.

General remarks.—Berries very attractive and sweet, taste very good. If it were a little more juicy it would have been an excellent variety.

4. Hybrid Seedling No. 22/11.—A cross between Waltham Cross and Rose.

Bunch.—Small rather loose.

Berries.—Dark red, oblong, small to big in size.

Ripening.—Uniform.

Skin.—Very thick and leathery.

Pulp.—Green, quite pulpy, sweet and of excellent taste and flavour.

Seeds.—1-2.

Total soluble solids.—30.2.

General remarks.—Berries attractive but not uniform in size, taste and flavour very good.

5. Hybrid Seedling No. 18/19.—A cross between Foster's Seedling and Kandhari.

Bunch.—Small to medium, loose, tapering.

Berries.—Round black heavily bloomed, small to big, great variation in size.

Ripening.—Uniform.

Skin.—Thick leathery.

Pulp.—Green very juicy melting and sweet, very good in taste and flavour.

Seeds.—2-3 generally 2 in each berry.

Total soluble solid.—22 per cent.

General remarks.—It is the best and early ripening black variety.

6. Hybrid Seedling No. 19/6.—A cross between Foster's Seedling and Kandhari.

Bunch.—Small, shape not well defined, compact.

Berries.—Small, round, dull red with plenty of bloom. Fully ripe berries dark red in colour.

Ripening.—Rather un-uniform.

Skin.—Thick and leathery.

Pulp.—Light green very juicy fairly sweet acidity marked, flavour agreeable.

Seeds.—Seedless.

Total soluble solids.—21.5 per cent.

General remarks.—Seems to be a good keeper. It is seedless cross with almost all the desirable characters.

7. Hybrid Seedling No. 19/4.—A cross between Foster's Seedling and Kandhari.

Bunch.—Medium, to big heavily bloomed, purple in colour, some variation in size.

Ripening.—Uniform.

Skin.—Thick, very leathery, does not dissolve in mouth.

Pulp.—Green very juicy, melting, sweet, with good taste and flavour. Good blend of acidity and sugar.

Seeds.—2-4.

Total soluble solids.—22.2 per cent.

General remarks.—A good early uniform ripening variety with good taste and flavour.

8. Hybrid Seedling No. 13/16.—A cross between Foster's Seedling and Bedana.

Bunch.—Medium, compact, tapering with not very distinct shoulders.

Ripening.—Uniform.

Berries.—Medium (Bigger than Quetta seedless) round, green.

Skin.—Rather thin, leathery, does not dissolve in mouth.

Pulp.—Green, very juicy melting and sweet. Good taste and flavour.

Seeds.—2-3.

Total soluble solids.—19 per cent.

General remarks.—A good early ripening variety of high quality.

9. Hybrid Seedling No. 13/18.—A cross between Foster's Seedling and Bedana.

Bunch.—Big, very compact, tapering.

Berries.—Medium rather round or short oval, green.

Ripening.—Very uniform.

Skin.—Thin, leathery does not dissolve in the mouth.

Pulp.—Green very juicy melting sweet tasty with good flavour.

Seeds.—2-3 small in size.

Total soluble solids.—19.2.

General remarks.—The bunches are big and quite attractive. This seems to be a very good variety.

10. Hybrid Seedling No. 11/6.—A cross between Foster's Seedling and Bedana.

Bunch.—Very long, tapering, big size, fairly compact.

Berries.—Medium, round to oval, size of berries uniform, colour green.

Ripening.—Uniform.

Skin.—Green comparatively thinner and leathery.

Pulp.—Light green, juicy, melting, sweet, flavour very marked.

Seeds.—2.

Total slouble solids.—22.1 per cent.

General remarks.—Size of bunch, uniformity of berries and ripening with characteristic flavour are points in its favour. It seems to be a very good early green variety.

11. Hybrid Seedling No. 11/10.—A cross between Foster's Seedling and Bedana.

Bunch.—Small, tapering rather loose.

Berries.—Short oval to oval, green medium in size, small sized seedless berries present.

Ripening.—Uniform.

Thin.—Green, rather thin but leathery.

Pulp.—Light green, juicy melting. Flavour very pronounced.

Seeds.—2-4.

Total soluble solids.—22.2 per cent.

General remarks.—Excepting the size of the bunch it is as good number 11/6.

12. Hybrid Seedling No. 12/4.—A cross between Foster's Seedling and Bedana.

Bunch.—Small tapering rather loose.

Berries.—Green small to medium short oval. The small berries of seedless.

Ripening.—Uniform.

Skin.—Green thick and leathery.

Pulp.—Light green, juicy melting, sweet with a pronounced flavour.

Seeds.—1-2.

Total soluble solids.—20.5 per cent.

General remarks.—With good taste and flavour and uniform ripening, this seedling seems to be a quite good cross for further propagation.

13. Hybrid Seedling No. 37/6.—A cross between Pandhari Sahebi and Chasseles rose.

Bunch.—Medium tapering fairly compact.

Berries.—Medium, oval, pale green with a few small seedless berries.

Ripening.—Uniform.

Skin.—Pale green thick and leathery.

Pulp.—Light green, juicy, melting, very sweet, marked agreeable flavour.

Seeds.—2.

Total soluble solids.—23.4.

General remarks.—It is one of the best early ripening white crosses.

14. Hybrid Seedling No. 16/6.—A cross between Foster's Seedling and Khalili.

Bunch.—Medium, shape not well defined as many berries had already dropped, loose.

Berries.—Green, short oval, size medium, small seedless berries present.

Ripening.—Uniform.

Skin.—Green, thin though leathery but dissolves in the mouth.

Pulp.—Green, juicy melting quite sweet with pronounced flavour.

Seeds.—2-3 generally 2.

Total soluble solids.—20 per cent.

General remarks.—This is also a fairly good cross.

Conclusion

As will be evident from the foregoing data the several hybrid seedlings gave a total soluble solids percentage of 20 and over and some of the types have produced high quality fruit considering from various standpoints of bunch berry characters yields etc. The hybrids are far superior not only to their parents but also the existing varieties recommended by the department for cultivation in the Punjab plains. Unfortunately due to some climatic factors, the skin invariably becomes, thickened and does not get dissolved readily as is in the Quetta grapes. Moreover, yields in almost all the cases do not compare favourably with the Quetta and Chaman grapes. The main point in favour of these hybrid seedlings is that they come into market at a time when Baluchistan grapes are not ripened. Thus there seems to be some scope for their cultivation on a semi-commercial scale in the Punjab plains. In spite of all this there seems to be hardly any possibilitly of their large-scale cultivation under these conditions, as the lucrative returns from citrus and mango fruits in the plains are a deterring factor in the expansion of areas under grapes.

Although considerable improvement over the original parents was effected by hybridization, the climate being a limiting factor is suggestive of carrying out this work in Soon Valley where we have a milder climate and there are no summer rains.

Acknowledgement

The authors are indebted to earlier workers, Dr. Sham Singh and Lal Singh who initiated the systematic studies on grapes for their classification etc. in the year 1933. Some of the descriptive data reported herein were collected by these workers.

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CITRUS ROOTSTOCK INVESTIGATIONS IN THE FORMER PROVINCE OF PUNJAB

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ACCORDING to authentic historic records most of the important commercial species of citrus originated from Asiatic countries like Assam, Cochin and China. People of this subcontinent were quite familiar with the cultivation of such fruits from times of Mughal Emperor Akbar and a mention of this fact has been made in the famous book "Ain-e-Akbari". Citrus fruits are well known for their dietetic and therapeutic values. They are also a rich source of vitamins especially vitamin 'C' which is known for its anti-scurvy properties. It is naturally quite imperative, therefore, that proper attention to the scientific cultivation of these fruits be given to improve production both in quantity and quality. Although fruit growing including citrus fruits was known to the man from times immemorial, yet it remained more or less a hobby with the rich people to satisfy their fancy. The idea of commercial production is only very recent. The researches carried out on various aspects of fruit growing have equipped the people with scientific knowledge for increasing yields and improving production, thereby bringing lucrative returns to the growers and giving impetus for the expansion of areas under various fruits. Since vast stretches of land in this province are suitable for the cultivation of citrus fruits, the area under citrus has been increasing at a rapid pace. Thus with the increase in area and production, the need for authentic information on various technical implications of horticulture has been increasingly felt by the people. No doubt manuring irrigation and other cultutral operations contribute substantially towards successful cultivation of such fruits, the selection of right type of rootstocks for various scion varieties cannot be ignored without seriously jeopardizing the citrus industry of the country. That a proper selection of rootstocks for cultivated citrus species plays a most important role in the orchard economics and makes all the difference between the success and failure of a plantation, are facts established beyond doubt both by common observation and scientific findings.

OBJECT OF THE PROJECT

The most economic and widely accepted method of propagating citrus fruits in all the countries is only shield-budding a selected scion variety on a suitable rootstock. The compatibility or degree of congeniality of a stock scion combination, has, according to investigational work carried out in Indo-Pakistan subcontinent and elsewhere, been found to be dependant upon the stocks used and soil and climatic conditions under which the specific stocks are grown. Thus one of the outstanding problems that must be solved before the development of citrus industry on sound lines is "the determination of kind of stock to be used for various varieties of citrus trees". Kind of stock to be used has such a great bearing on the longevity of fruit

trees, size of trees, yield and quality of fruits, resistance of trees to various diseases, frost and other environments, in short, on the very success of citrus trees that this important problem cannot be ignored.

This problem has received considerable attention at the hands of citrus experts of foreign countries, who after a good deal of work have come to certain conclusions as to the best rootstock for citrus trees suitable for their respective localities. No doubt their results throw a flood of light and to a certain extent even indicate the probable stocks that might prove successful here, but as our climate and soil and other conditions as well as the varieties of citrus grown are somewhat different from theirs, we undoubtedly cannot derive very much benefit from the results of their experiments.

With this end in view rootstock investigations were initiated at Lyallpur in the year 1932 and after only four years, *i.e.*, in 1936 the scheme of citrus rootstock experiments was started at Montgomery. The project also included grape-vine, hybridization work and was financed by the Imperial Council of Agricultural Research. In this write-up only citrus-stocks investigations have been discussed. As already stated, the researches carried out in various countries have established beyond doubt that rootstocks play an important role in fruit growing, so much so that the very success of such enterprise depends, on a large extent, on the compatibility or congeniality of these stock scion combinations. It was therefore felt imperative that detailed investigations on the influence of various stocks on commonly grown scions be taken up on proper lines under our conditions of climate and soils. The scheme was thus started in August, 1936 at Montgomery with the following aims in view:—

(*i*) To find out the best rootstocks for the important commercial citrus fruits grown in the province.

(*ii*) To find out control measures for common citrus diseases.

REVIEW OF LITERATURE

The success of a stock scion combination is markedly affected by both soil and climate, since it is well known that a given rootstock which is satisfactory in one country or locality, may be a complete failure in another (Brown 1920; Powell 1930; Toxopeus 1937; Webber, 1925, Tukey, 1939; McCown, 1958). Furthermore, certain rootstocks are known to exert a considerable influence on the vigour, cropping etc. of the scion varieties budded or grafted on them (Brown, 1920, Bonns and Mertz, 1916, Batchelor and Webber, 1939, Hatton, 1927, 1928-29; 1931; 1935; Hodgson and others, 1937; Quinn 1932; Rogers, 1926, Rogers and Vyvyan 1928; Singh 1936; Tydeman, 1926-27; Webber, 1934; Richards, 1938, Bitters and Batchelor, 1951; McCown, 1958). Certain scions under appropriate conditions show an equally noticeable effect on certain rootstocks (Amos and others 1930; Brown, 1920; Halma, 1934; Hass and Halma, 1929; Hatton, 1923; 1927; Roberts, 1929; 1931; Swarbrick, 1927; 1931; Tukey and Brase, 1933; Webber, 1919; Wormald and Grubb, 1924; Vyvyan, 1930) Recent rootstock investigations, especially in England and America where considerable work has already been carried out on the problems arising directly from the twofold structure of a fruit tree, have emphasized the need for standardized material for all types of investigation. The fruit quality is definitely affected by the rootstocks used. Bitters (1951), Singh and Singh (1944-45) in their investigations on rootstock effect on fruit quality have observed that %age of juice, peel, rag, acidity, sugar etc. are profoundly influenced by various stocks used in the experiments.

Prior to the present investigations, growers had vague and varied impression of the so-called rootstock effect and it is, therefore, not surprising that all sorts of rootstocks were in common use. Such popular fallacies that "sweet lime" (*Citrus aurantifolia* Swingle) was a better stock for producing fine quality mandarins and that 'mokari' and galgal could produce vigorous and prolific plants were very common. Without authentic data people were only *groping* in darkness. The prevalence of low yields, inferior fruit quality and the early decline of large number of trees in our gardens was due to a large measure to the indiscriminate use of miscellaneous rootstocks by nursery men of Indo-Pak subcontinent.

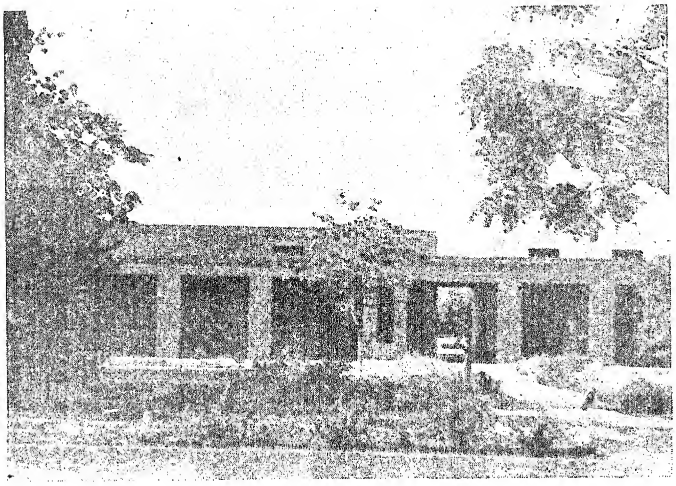


PLATE I.—Horticultural Research Sub-Station, Montgomery.

PLATE II.—Another view of the Research Sub-Station.

The available evidence on rootstock investigations points to the fact that the performance of a budded or grafted plant is an expression of the reciprocal effect of the two symbionts. On this basis rootstocks have been designated as vigorous or dwarf, etc., but since the vigour of different scion varieties and species on the same rootstock is known to be different (Hatton 1935; Roberts 1929), the term vigorous and dwarf must be regarded as purely relative. Not only this, the findings of various workers (Barker, 1927; Robert, 1929; Singh, 1936; Tukey and Brase, 1933) show that a scion variety has apparently an inherent growth capacity which it normally exhibits, a capacity which may be dwarfed very considerably, but which apparently may not be increased beyond a very small amount. This conclusion leads directly to the suggestion that in all cases where rootstock influence is a limiting factor to tree size, it is of a dwarfing factor. Roberts (1929) goes even as far as to suggest a classification of rootstocks on this basis. According to Hatton (1926) the so-called vigorous rootstocks are really neutral since they do not, in any way, limit the free development of the scion. Dwarfing rootstocks, on the other hand, are dominant since they do not allow the scion to develop to its natural capacity.

Finance and Staff

In response to the research scheme on citrus stocks, which also included grapevine hybridization project, submitted by the Agriculture Department, the Imperial Council of Agriculture Research sanctioned a sum of Rs. 57,430 with effect from August, 1936 extending over a period of five years. The actual work on the scheme, started from November 11, 1936 with the appointment of Assistant Horticulturist.

The Fruit Specialist, Punjab Agricultural College, Lyallpur, supervised the working of the scheme honorarily. The staff sanctioned in the scheme was as under:—

(*i*) Assistant Horticulturist in the grade of Rs. 250-25-550/25-750.

(*ii*) Two Horticultural Assistants in the grade of Rs. 100-10-200/10-300.

(*iii*) One Mycological Assistant.

(*iv*) One clerk in the grade of Rs. 50-3-80/4-100.

From its inception till 31st July, 1941 the scheme was financed by the Imperial Council of Agricultural Research and the Punjab Government in the ratio of 2: 1 and the income realized from the scheme was also shared on the same basis. From 1st of April, 1946 the scheme was entirely taken over by the Punjab Government.

Since the rootstock experiments are longtermed and the behaviour of various rootstocks had to be studied for the entire economic bearing age of the trees, the scheme was made a permanent feature of the Fruit Section and a permanent post of Assistant Horticulturist was sanctioned by the Government. The work on citrus diseases was, however, discontinued from 1st April, 1944. The research work continued well up to partition of the subcontinent when it received a serious set-back as the post of Assistant Horticulturist was then retrenched and entire work of rootstock investigations was entrusted to one research assistant. After losing much valuable time, the Punjab Government was kind enough to again sanction the post of Assistant Horticulturist in the year 1952 for a period of one year in the first instance. The scheme has been extended from year to year until recently when the post of Assistt. Horticulturist was made a permanent one. Thus after partition the first Assistant Horticulturist joined the post in September, 1952. The sub-station, however, was transferred to the Deputy Director of Agriculture, Montgomery in the year 1953 and again it was transferred to the Fruit Section and regular appointment of Assistant Horticulturist was made in the year 1955 on temporary basis. Due to the transfer of the sub-station to the extension staff much valuable time, which could otherwise have been utilized for the useful investigational work, has been remorselessly wasted. The scheme was entirely financed by the Punjab Government until 1959. The Food and Agriculture Council of Pakistan provided funds for 1960 for the scheme. The present sanctioned staff is as under:—

(1) One Assistant Horticulturist.

(2) One Peon.

One Research Assistant of the general section is posted at Montgomery. He is required to handle stores, cash, office routine work etc. in addition to assisting the Assistant Horticulturist in the collection of data and general maintenance of garden and nursery of the sub-station.

STATUS AND IMPORTANCE OF VARIOUS ROOTSTOCKS

It may be interesting as well as helpful, if it is briefly summarized here the extent to which each stock is being used in citrus growing countries and the relative popularity and success of each.

(*a*) **U.S.A.**

Sour Orange (*Citrus aurantium*) and sweet orange (*Citrus sinensis*) had been the only two rootstocks for sweet oranges largely used in California. The citrus growers of U.S.A. claim for sour orange, the following characteristics:—

(1) This rootstock is extensively used for citrus wherever soils are low, wet or heavy as, for instance, in the India River section, in Florida.

(2) It is highly resistant to foot rot and tolerant to xyloporosis, but is highly susceptible to tristeza.

(3) Sour orange is a slow grower on light, sandy soils.

(4) Of the commonly used rootstocks sour orange is second only to the Trifoliate, orange in cold hardiness.

(5) Although it produces fruit of outstanding quality, its use for commercial plantings in the future seems unwise in view of the Tristeza problem.

(6) It is a good stock for heavy and humid soils.

Rough Lemon (*Citrus limon* Linn)

(1) It is most widely used rootstock, particularly for plantings on the light, sandy, well drained soils, it is a vigorous grower and produces large trees much faster than other rootstocks and bears heavy crops.

(2) It is highly tolerant to tristeza and xyloporosis, but is susceptible to root and crown rot. Like all other rootstocks it is also subject to attack by various nematodes hat plague citrus.

(3) The fruit produced is of poorer quality as compared to that produced by sour orange, sweet orange, cleopatra and trifoliate orange.

(4) Rough lemon cannot be recommended for colder areas.

(5) It is drought-resistant when choosing between rough lemon, sweet orange and cleopatra rootstocks for light, sandy well-drained soils, one must weigh the advantages of increased yields by rough lemon against the improved quality and suitable crops of the other two.

Cleopatra (*Citrus reticulata*)

(1) It is adaptable to a wide range of soils, the trees grow well in the deep sands as well as in the low, moist soils of the coastal areas. However, in the very light sands, the fruit crops of most scion varieties on this stock have been disappointing in amount and size of fruit.

(2) Cleopatra is tolerant to xyloporosis and tristeza and promises considerable resistance to foot rot.

(3) It produces fruit of excellent quality and is a preferred stock for Mandarin type scion varieties, especially temple and tangelos.

(4) It comes into bearing more slowly than rough lemon.

(5) It produces fruit of small size in case of Hamlin scion variety.

(6) Valencia and grape-fruit when budded on this stock give comparatively lower yields than when budded on rough lemon.

(7) Cold hardiness of this stock is more than rough lemon, but less than sour orange.

Sweet Orange (*Citrus sinensis*)

It possesses the following characteristics:

(1) Unlike sour stock it is very susceptible to foot rot. It is tolerant to tristeza and xyloporosis.

(2) It is adaptable to light, sandy soils and well-drained, heavier soils.

(3) Scion production on this is second to rough lemon for sweet orange and grapefruit varieties.

(4) It falls between rough lemon and sour orange in cold hardiness.

(5) The quality of fruit produced on this stock is generally good.

(6) It is reported to have a more shallow root system than sour orange.

Trifoliate orange (*Poncirus trifoliata*)

(1) It is well known for its cold hardiness.

(2) It is very popular for clay soils and those of a heavy compact nature. It, however, has a dwarfing effect on scions budded on it. It is, therefore, used to advantage for landscaping small properties.

(3) When used as rootstock it produces fruit of excellent quality and gives good production per volume of tree.

(4) It is well known for great abundance of fibrous roots.

(5) In Albama state satsuma on this stock is of better growth, gives better fruits, higher yield and ripens earlier than those grown on other rootstocks.

(*a*) **Pakistan:**

In Pakistan "Jatti Khatti" (Rough lemon) "Sour Orange", "Kharna Khatta" (*Citrus karna* Ref) "Mokari" (*Citrus medico* Linn) "sweet lime" (*Citrus aurantifolia* Swingle) are commonly used.

Jatti Khatti or Rough lemon (*Citrus limon* Linn)

(1) It is generally believed to be a good stock for all the scion varieties especially for malta blood-red.

(2) It is quite susceptible to gummosis.

(3) It produces large sized trees more quickly.

(4) Its drought-resistance is great.

(5) It produces trees with tall upright centre.

Sour Orange (*C. aurantium* Linn)

This stock has only been tried in the case of Valencia late variety of sweet orange. This stock has improved the quality of Valentia late.

Kharna Khatta (*C. Karna* Raf)

(1) It appears to be a universal stock, as it has done well with almost all the scions budded on it. It has been found to be incompatible for malta blood-red.

(2) It is associated with vigorous plants in malta common, sangtra local and grape fruit Marsh seedless.

All the trials have been conducted under Montgomery conditions, therefore behaviour of stocks under different conditions of soils and climate cannot be discussed.

(3) Its nursery performance is also very good. Germination as well as rate of growth and bud take is quite good.

Mokari and Mitha (*Citrus medica* Linn *and Citrus aurantifolia* Swingle)

(1) These rootstocks give a good nursery performance.

(2) Both of them are very dwarfing.

(3) Sweet lime is known for increasing T.S.S. in mandarins, but percentage of juice is comparatively low.

(4) Popular fallacies in the growers about suitability of 'Mokri' as stock for mandarin have not come true.

The present investigations envisaged the collection and inclusion of exotic as well as local rootstocks in trials for determining suitable stocks for commonly grown citrus scion varieties. Since, according to researches carried out in other countries, rootstocks have been found to behave differently under different soil and climatic conditions, it was felt necessary that rootstocks in this country be selected after trial under our conditions. Unfortunately, this work was only confined to Horticultural Research Sub-station, Montgomery and the results obtained at this place cannot be considered to be wholly applicable to other places. Anyhow the results of these experiments are a great boon for citrus growers as the Montgomery soils and climate are almost representative of the major citrus growing areas of the Punjab plains.

It is well known that certain rootstocks have affinity or greater degree of adaptability for certain types of soils, whereas others do not thrive well under such conditions. Since the present investigations were carried out in one set of conditions it will be of interest if analysis of soil and subsoil where the trials were conducted, is also given here. Tables 1 & 2 show the mechanical as well as chemical analyses of various plots where these experiments have been carried out at Montgomery.

TABLE 1

Horticultural Research Sub-station, Montgomery, Soil Analysis (Mechanical) (per 100 Gms. Air dried).

Serial No.	Register No.	Clay 0-0,002 mm.	Silt 0.002-0.02 mm.	Fine Sand 0.02-0.2 mm.	Sand 0.2-2.0 mm.	Gravel above 2 mm.	Total Carbo-nates as $CaCO_3$	Organic matter	Total Nitrogen 'N'	pH Values	Remarks	
1	826 ...	14.61	24.35	61.04	Traces	...	...	...	...	...	Plot 8	1′
2	827 ...	15.12	27.44	57.44	,,							2′
3	828 ...	14.00	30.24	55.76	,,							3′
4	829 ...	13.63	36.78	49.59	,,							4′
5	830 ...	12.59	39.09	48.32	,,							5′
6	831 ...	12.35	37.87	49.78	,,							6′
7	832 ...	15.12	31.12	53.76	,,	...	...	...	...	...	Plot 9	1′
8	833 ...	15.50	27.14	57.36	,,							2′
9	834 ...	15.58	26.80	57.62	,,							3′
10	835 ...	12.70	35.82	51.48	,,							4′
11	836 ...	14.36	40.08	45.56	,,							5′
12	837 ...	14.48	38.20	47.32	,,							6′
13	838 ...	13.28	19.26	67.46	,,	...	...	...	...	...	Plot 4	1′
14	839 ...	12.54	18.38	69.08	,,							2′
15	840 ...	12.26	17.98	69.76	,,							3′
16	841 ...	11.82	17.06	71.12	,,							4′
17	842 ...	11.14	16.96	71.90	,,							5′
18	843 ...	10.12	19.48	70.40	,,							6′
19	844 ...	14.68	24.72	60.60	,,	...	...	...	...	...	Plot 5	1′
20	845 ...	14.30	24.26	61.44	,,							2′
21	846 ...	12.14	23.94	63.92	,,							3′
22	847 ...	11.02	25.92	63.06	,,							4′
23	848 ...	9.06	25.72	65.22	,,							5′
24	849 ...	11.22	35.50	53.28	,,							6′

TABLE 1—(*Continued*)

Serial No.	Register No.	Clay 0-0.002 mm.	Silt 0.002-0.02 mm.	Fine Sand 0.02-0.2 mm.	Sand 0.2-2.0 mm.	Gravel above 2 mm.	Total Carbo-natesas Ca_1CO_3	Organic matter	Total Nitrogen 'N'	pH Values	Remarks	
25	850 ...	13.84	24.02	62.14	Traces	...	...	...	...	...	Plot 10	1′
26	851 ...	13.60	24.72	61.68	,,							2′
27	852 ...	14.16	25.38	60.46	,,							3′
28	853 ...	12.76	26.04	61.20	,,							4′
29	854 ...	11.66	28.94	59.40	,,							5′
30	855 ...	11.34	33.92	54.74	,,							6′
31	856 ...	14.32	23.92	61.76	,,	...	...	...	...	...	Plot 11	1′
32	857 ...	14.60	26.88	58.52	,,							2′
33	858 ...	14.13	27.81	58.06	,,							3′
34	859 ...	13.66	29.62	56.72	,,							4′
35	860 ...	12.42	34.44	53.14	,,							5′
36	861 ...	12.20	37.90	49.90	,,							6′
37	862 ...	12.62	22.06	65.32	,,	...	...	...	...	...	Plot 2	1′
38	863 ...	11.58	28.84	69.58	,,							2′
39	864 ...	10.90	18.48	70.62	,,							3′
40	865 ...	10.30	18.46	71.24	,,							4′
41	866 ...	10·22	20.06	69.72	,,							5′
42	867 ...	7·14	20.38	72.48	,,							6′
43	868 ...	13.72	23.42	62.86	,,	...	...	...	...	...	Plot 3	1′
44	869 ...	13.68	21.60	64.72	,,							2′
45	870 ...	13.28	20.88	65.84	,,							3′
46	871 ...	12.34	20.54	67.12	,,							4′
47	872 ...	9.78	22.78	67.44	,,							5′
48	873 ...	9.76	23.64	65.60	,,							6′

TABLE 2

Horticultural Research Sub-station, Montgomery Soil Analysis (Chemical).

Serial No.	Register No. 1939 S	Total Solids	Carbonates, 'Na_2CO_3'	Bicarbonates $NaHCO_3$'	Chlorides 'NaCl'	Sulphates 'Na_2SO_4'	Calcium 'Ca'	Sodium 'Na'	Ratio of Sodium to Calcium 'Na : Ca'	pH Values glass electrode	Stratum foot	Remarks
1	826 ...	0.118	0.004	0.063	0.021	0.035	0.013	0.006	32 : 68	8.36	1st	Plot No. 8.
2	827 ...	0.117	0.004	0.055	0.032	0.033	0.015	0.008	35 : 65	8.30	2nd	
3	828 ...	0.221	0.004	0.055	0.044	0.118	0.026	0.024	48 : 52	8.19	3rd	
4	829 ...	0.281	0.004	0.046	0.073	0.161	0.026	0.049	65 : 35	8.30	4th	
5	830 ...	0.434	0.005	0.038	0.114	0.273	0.036	0.077	68 : 32	8.38	5th	
6	831 ...	0.448	0.005	0.038	0.143	0.258	0.036	0.088	71 : 29	8.30	6th	
7	832 ...	0.185	0.004	0.072	0.041	0.069	0.024	0.014	37 : 63	8.10	1st	Plot No. 9.
8	833 ...	0.144	0.004	0.063	0.029	0.052	0.017	0.014	45 : 55	8.28	2nd	
9	834 ...	0.271	0.004	0.046	0.038	0.179	0.038	0.029	43 : 57	8.13	3rd	
10	835 ...	0.427	0.003	0.047	0.047	0.324	0.053	0.049	48 : 52	8.19	4th	
11	836 ...	0.374	0.004	0.038	0.053	0.269	0.040	0.052	56 : 44	8.20	5th	
12	837 ...	0.379	0.003	0.038	0.053	0.270	0.044	0.052	54 : 46	8.17	6th	
13	838 ...	0.085	0.004	0.055	0.009	0.012	0.009	0.002	18 : 82	8.59	1st	Plot No. 4.
14	839 ...	0.079	0.004	0.055	0.012	0.012	0.008	0.005	38 : 62	8.58	2nd	
15	840 ...	0.087	0.005	0.054	0.012	0.014	0.010	0.004	29 : 71	8.58	3rd	
16	841 ...	0.113	0.005	0.054	0.032	0.021	0.013	0.003	19 : 81	8.48	4th	
17	842 ...	0.130	0.004	0.063	0.023	0.043	0.011	0.013	54 : 46	8.52	5th	
18	843 ...	0.213	0.004	0.046	0.030	0.129	0.019	0.013	40 : 60	8.38	6th	
19	844 ...	0.082	0.004	0.063	0.006	0.011	0.009	0.004	31 : 69	8.53	1st	Plot No. 5.
20	845 ...	0.086	0.004	0.063	0.012	0.011	0.014	0.003	18 : 82	8.52	2nd	
21	846 ...	0.086	0.005	0.062	0.009	0.014	0.012	0.008	40 : 60	8.62	3rd	
22	847 ...	0.097	0.005	0.054	0.018	0.027	0.010	0.016	61 : 39	8.69	4th	
23	848 ...	0.121	0.004	0.046	0.018	0.058	0.015	0.016	51 : 49	8.63	5th	
24	849 ...	0.241	0.004	0.046	0.015	0.172	0.032	0.025	44 : 56	8.38	6th	

TABLE 2—(*Continued*)

Serial No.	Register No. 1939 S	Total Solids	Carbonates, 'Na$_2$CO$_3$'	Bicarbonates 'NaHCO$_3$'	Chlorides 'NaCl'	Sulphates 'Na$_2$SO$_4$'	Calcium 'Ca'	Sodium 'Na'	Ratio of Sodium to Calcium 'Na : Ca'	pH Values glass electrode	Stratum foot	Remarks
25	850 ...	0.095	0.004	0.072	0.012	0.014	0.010	0.007	41 : 59	8.78	1st	Plot No. 10
26	851 ...	0.109	0.004	0.072	0.012	0.018	0.011	0.009	45 : 55	8.57	2nd	
27	852 ...	0.155	0.004	0.055	0.012	0.091	0.023	0.005	16 : 84	8.22	3rd	
28	853 ...	0.169	0.904	0.046	0.021	0.103	0.022	0.015	40 : 60	8.39	4th	
29	854 ...	0.333	0.003	0.047	0.050	0.242	0.035	0.043	55 : 45	8.47	5th	
30	855 ...	0.331	0.003	0.047	0.041	0.244	0.031	0.051	62 : 38	8.47	6th	
31	856 ...	0.109	0.004	0.072	0.021	0.010	0.012	0.005	30 : 70	8.55	1st	Plot No. 11
32	857 ...	0.121	0.004	0.072	0.029	0.021	0.013	0.009	41 : 59	8.35	2nd	
33	858 ...	0.141	0.004	0.072	0.032	0.040	0.015	0.016	52 :48	8.34	3rd	
34	859 ...	0.201	0.004	0.055	0.041	0.097	0.020	0.029	60 :40	8.40	4th	
35	860 ...	0.210	0.004	0.063	0.038	0.103	0.016	0.042	72 : 28	8.45	5th	
36	861 ...	0.267	0.004	0055	0.056	0.149	0.020	0.046	70 : 30	8.45	6th	
37	862 ...	0.105	Traces	0.059	0.025	0.026	0.010	0.012	55 : 45	8.44	1st	Plot No. 2
38	863 ...	0.107	,,	0.059	0.020	0.030	0.016	0.014	47 : 53	8.40	2nd	
39	864 ...	0.131	,,	0.067	0.025	0.042	0.018	0.013	42 : 58	8.60	3rd	
40	865 ...	0.233	,,	0.059	0.041	0.133	0.024	0.030	55 : 45	8.40	4th	
41	866 ...	0.209	,,	0.059	0.053	0.103	0.018	0.037	67 : 33	8.30	5th	
42	867 ...	0.189	,,	0.059	0.044	0.091	0.013	0.035	73 : 27	8.60	6th	
43	868 ...	0.124	0.003	0.064	0.006	0.056	0.017	0.006	26 : 74	8.63	1st	Plot No. 3
44	869 ...	0.118	0.005	0.062	0.009	0.042	0.008	0.016	66 : 34	9.20	2nd	
45	870 ...	0.168	0.005	0.062	0.015	0.083	0.017	0.030	64 : 36	8.89	3rd	
46	871 ...	0.301	0.004	0.055	0.035	0.209	0.032	0.046	59 : 41	8.40	4th	
47	872 ...	0.299	0.004	0.046	0.041	0.204	0.030	0.058	66 : 34	8.51	5th	
48	873 ...	0.343	0.004	0.046	0.044	0.241	0.032	0.062	66 : 34	8.45	6th	

COLLECTION OF ROOTSTOCK VARIETIES, THEIR CLASSIFICATION AND NOMENCLATURE

A large number of rootstocks were collected from all parts of Indo-Pakistan subcontinent with a view to remove the confusion about their nomenclature after studying their morphological characters and to study their influence on various scion varieties. Seeds as well as cuttings of these varieties were, as far as possible, obtained from the same parent tree in each case. In all 40 strains from seeds were raised successfully out of which 26 could also be propagated by vegetative means. This material was planted at H.R.S.S. MGY in plot No. 1 in February, 1934 with the following aims and objects:—

(*a*) To compare the performance of the progeny plants produced from any particular variety by (*i*) hardwood cuttings and (*ii*) Apogamic seedlings.

(*b*) To rectify the confusion about the nomenclature of these varieties through a detailed study of their morphological and pomological characters.

The exact No. of species in the various genera of subfamily Aurantiadae has never been agreed by the various taxanomists. No common classification was acceptable to all. Many hybrids have been described as separate species while Swingle (1934) basing his classification on the species met by him in the herbaria of Europe, China and America, described only 10 species and 4 varieties in the sub-genus Papeda, *i.e.*, 16 species and 8 varieties in the genus citrus. He never came to the Indo-Pakistan subcontinent where evolution of most of the citrus species took place and where lot of material for classification is available. He, therefore, missed in his classification many species, varieties and hybrids which Tanaka (1937) named and described during his tour of the subcontinent.

Workers including Tanaka, who described the oriental citrus species, always had conflicting views about many citrus fruits. Bonavia (1890), for example, described "Kharna Khatta" as a variety of sour orange (*Citrus aurantium* Linn), while Gandhi (1934) related this fruit to the rough lemon (*Citrus limon* Linn) Brown (1920) assumed this fruit to be a type of rough lemon. Similarly Atoni (also an indigenous fruit) has been considered differently by different authors. Bonavia (1890) considered this fruit as giant form of mandarin. Adopting this idea, Lushington (1910) described it as citrus chrysocarpa var. decumana. Tanaka (1937), on the other hand, assigned the name "citrus rugulosa" to this fruit. Similar is the case with many other indigenous and imported citrus fruits of the subcontinent.

The systematic studies in this connection were taken during March, 1937 when some of the rootstock varieties especially raised from cuttings started flowering. Data on the colour of petals, length and breadth of petals, number of stamens, colour and pubesence of new shoots and developing leaves, etc., were recorded. Besides this, length, breadth, colour, dentition, venation, and phyllotaxis of full-grown leave; length, thickness and characters of petioles were also studied. The fruit characters of some of the varieties that fruited have also been described. This line of work was adopted for the study of all the varieties under trial accordingly as they came into fruiting. The various phases of study were completed and have been reported individually in this report.

The height, girth and spread measurements of the varieties propagated both from seeds as well as hardwood cuttings were also made with a view to study the tree character as influenced by the method of propagation. The data had been worked out and reported separately under appropriate heads.

The information on morphological characters in respect of various stocks under trials is summarised below:

As will be seen in the text, the various rootstocks are known by the number allotted to them. The following names have been given after studying their morphological characters.

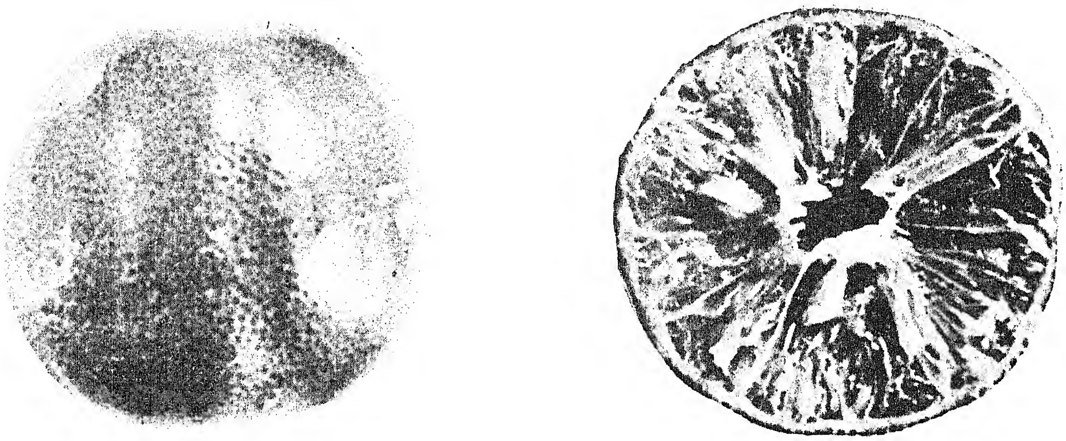


PLATE III.—MITHA—Sweet lime (*C. aurantifolia*, Swingle).

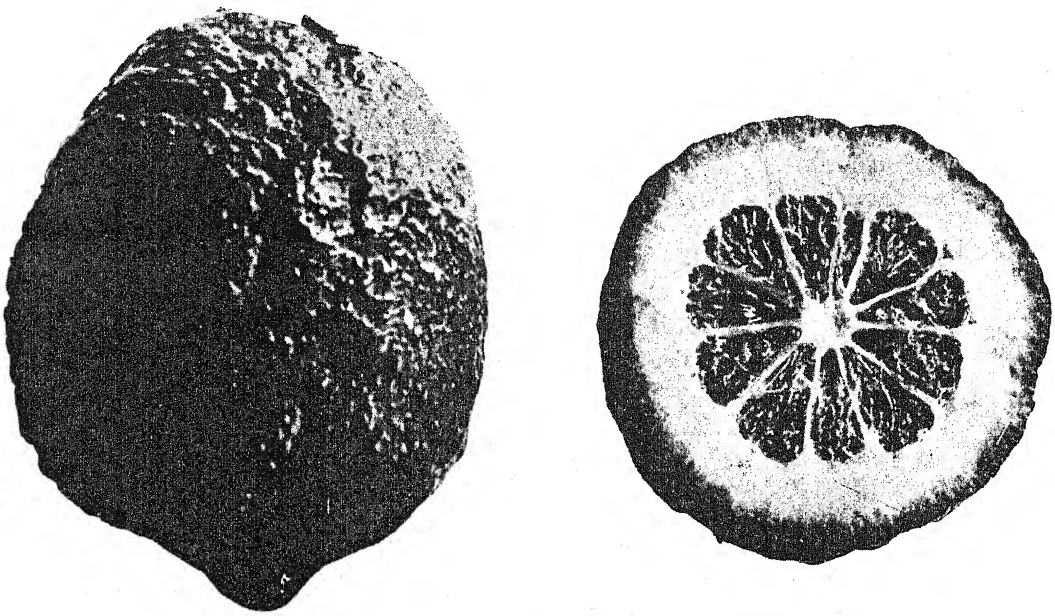


PLATE III. (*a*)—KHARNA KHATTA (*C. Karna* Raf.)

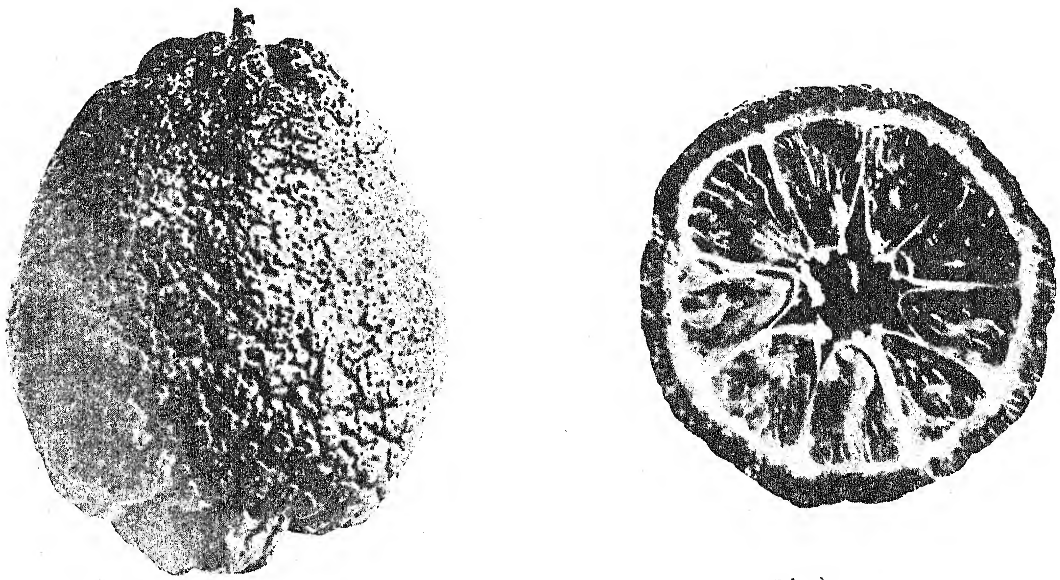


PLATE IV.—JATTI KHATTI, Rough lemon (*C. limon* Linn).

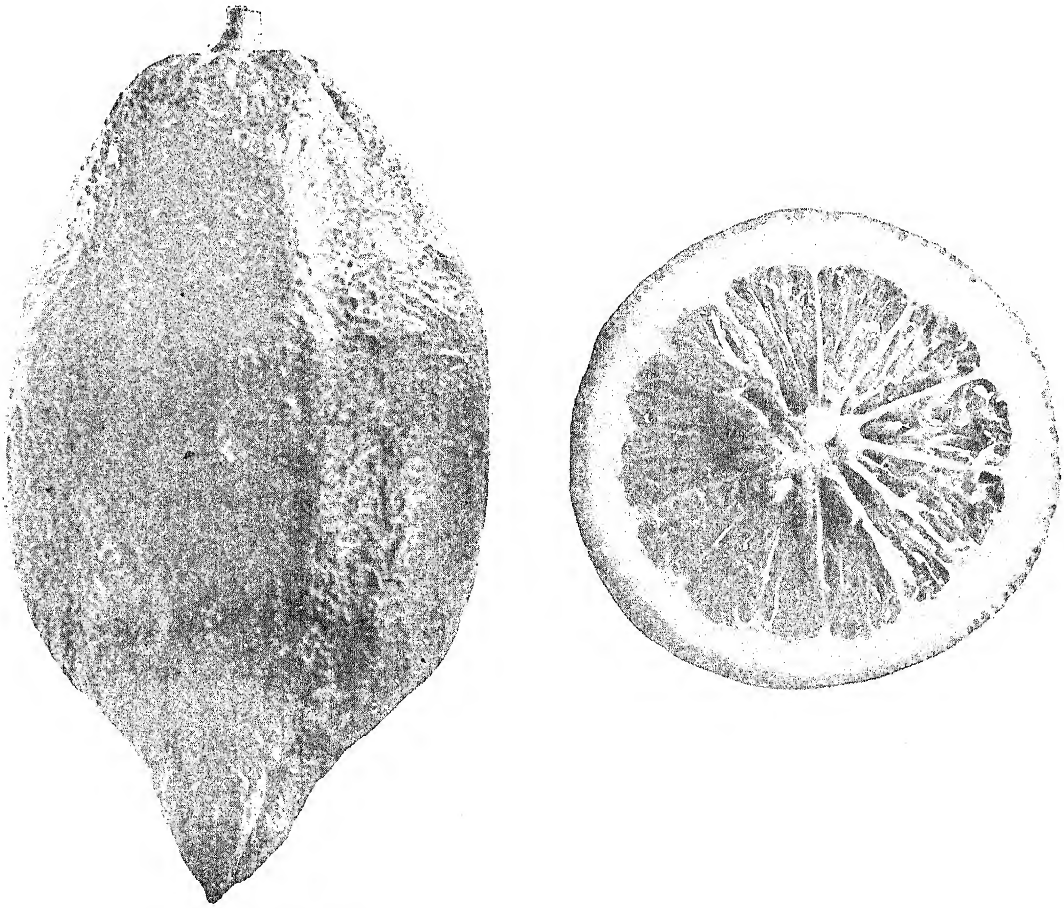


PLATE V.—MOKARI, Citron (*C. medica* Linn).

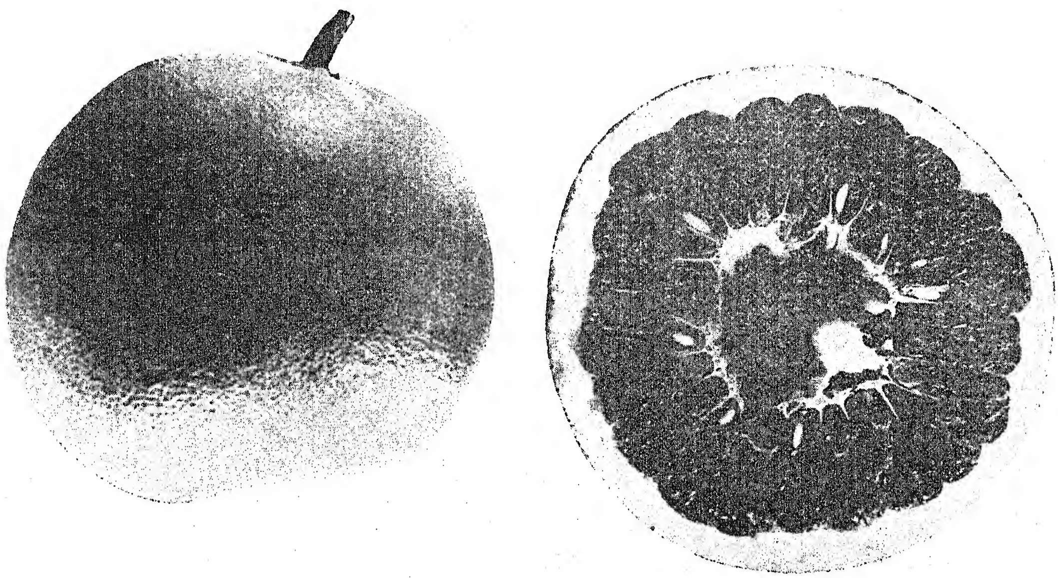


PLATE VI.—CHAKOTRA, Pummelo (*C. grandis* Linn).

PLATE VII.—Showing Compatibility in case of Blood Red budded on Jatti Khatti.

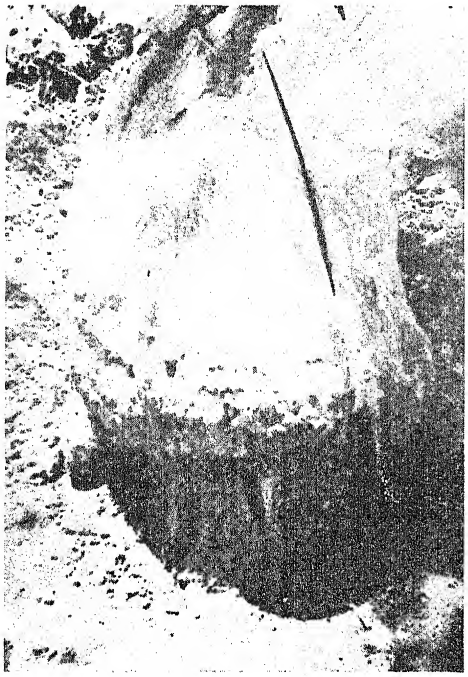


PLATE VIII.—Showing incompatibility of sweet lime when budded over with Marsh seedless.

PLATE IX.—Showing incompatibility of Mokari stock when budded over with grape fruit Marsh seedless.

No.	Name of stock		Possible English name	Specific name
1	Jatti Khatti	...	Rough Lemon	*Citrus limon* Linn.
2	Jullundur Khatti	...	Smooth-Skinned lemon	do.
20	Jatti Khatti	...	Roughlemon	do.
38	do.	...	do.	do.
44	do.	...	do.	do.
21	Nasnaran	...	Nil	*Citrus aurantifolia* Swingle.
43	Kharna Khatta	...	Nil	*Citrus karna* Raf.
10	Mokari (R. K.)	...	Citron	*Citrus medica* Linn.
11	Kharna Khatta	...	Nil.	*Citrus karna* Raf.
50	Mitha	...	Sweet Lime	*Citrus aurantifolia* Swingle.
6	do.	...	do.	do.
47	Chakotra	...	Shaddock	*Citrus grandis* Linn.
9	Mokari	...	Citron	*Citrus medica* Linn.
	Gada Dehi	...	Nil	*Citrus aurantium* Linn.

No. 50: Mitha Chikna (Sweet lime). Trees are fairly vigorous and of spreading habit. Foliage, dark green above but light green on the under surface. Leaves oval but comparatively broader than rough lemon (No. 44) leaves.

No. 44: Jatti Khatti (Rough lemon). Trees vigorous and fairly spreading in habit; foliage light green with faint bronze colour in the developing leaves; leaf shape long oval margins bicrenate; petiole small and thin and petiolar wings present only in a rudimentary form; petal colour pink with little less intensity than in case of No. 43 (Kharna Khatta); ripe fruit colour midway between lemon yellow and orange. A well-developed nipple with prominent grooves present at the stigma end, skin thickness only medium, juice sac colour same as that of No. 50 seed content averages about 24 per fruit.

No. 20: Khatti (Rough lemon) the morphological characters of this rootstock are the same as noted for No. 44 above.

No. 43: Kharna Khatta (no equivalent English name). Tree and foliage characters closely resemble those of No. 44 (Rough lemon) except that petiolar wings are quite visible and petiole is longer and thicker; petal colour pink, size of flower buds and intensity of colour in the petal closely resemble those of No. 9 (citron). Ripe fruit colour orange red but not so intense as in the case of sour Florida, fruit fairly thick skinned with well developed nipple at the stigma end like citron fruits. Juice sac colour like that met with in sweet oranges (Maltas), seed content average about 36 per fruit.

No. 9: Mokari (Citron). Trees much more spreading than any of the rootstock varieties under trial size of trees medium; bark colour of shoots, characteristically yellow; foliage dark green, but light green on the under surface; leaf shape oval, leaf margin serrate, leaf simple with no trace of petiolar wings; petiole short and thick; size of flower buds and intensity of pink colour in the petals resemble those of No. 43 (Kharna Khatta) fruit thick skinned with well developed protruding nipple at the stigma ends. The character of the pithy part of the skin is hard and in contrast to the spongy character met with in case of pomelo or "Kharna Khatta"; ripe fruit colour lemon yellow, juice sac colour like that met with in lemon, seed contents averages around 100 per fruit.

No. 47: Chakotra (Pomelo). Trees comparatively of medium vigour, foliage dark green above but light green on the under surface. Leaf shape oval and margins crenate; developing shoots calyx pubescent; petiole small and thick and petiolar wings well developed; petal colour white, ripe fruit colour lemon yellow, rind smooth and thick skinned, the pithy part of the skin is spongy, juice vesicles well developed,

seed contents averages around 121 per fruit.

Jamberi. Jamberi tree was found to be similar to that of "Jatti Khatti", only notable difference was found in the fruit colour of "Jamberi", fruit is lemon yellow to lemon chrome whereas that of "Jatti Khatti" is apricot yellow to capucine yellow. Faint longitudinal ridges found occasionally on the surface of "Jatti Khatti" fruit are absent altogether in "Jamberi" fruit. Surface of both the fruits is coarsely papillate and rugose. Size is medium in both cases. Shape, however, differs. Jamberi fruit is round oblate whereas "Jatti Khatti" is obovoid or round ovoid. Density is low in both cases. Areolar areas in "Jamberi" fruit is always in the form of an elevated disc whereas in "Jatti Khatti" some fruits have their areolar areas in the form of elevated discs while others have them protruded into nipples. Areole is always a deep circular furrow in both cases. Adherence of rind to the segment ball is also identical and rind is equally thin. Number of segments rag form and rind is also similar. Percentage of juice is high in both the cases. Both are acid having little sugars. "Jamberi", therefore, must be included in the species citrus limon as the minor differences in fruit should be considered as varietal in magnitude. Hodgson (1937) and Hayes (1943) also agree to this and call "Jamberi" as Citrus limon. Singh and Singh (1942), however, have accepted Lushingtons name Citrus "Jamberi" for this fruit. Here it must be noted that the differences between European lemon and "Jatti Khatti" or rough lemon as described earlier, are much more as compared with those found in "Jamberi" and "Jatti Khatti" and if European lemon and "Jatti Khatti" have been placed in the same species there is no reason why "Jatti Khatti" and "Jamberi" should not be considered as varieties of the same species.

Mithi. Mithi also appears to be the variety of the species citrus limon—the species in which European lemon, "Jatti Khatti" and "Jamberi" have already been included. The tree, shoot, leaf and flower characteristics bear ample testimony to substantiate this fact. However, Mithi is conspicuous by the absence of purple colour of outer surface of the flower buds, of the lemon group in Mithi it is white. Fruit mostly resembles with that of "Jamberi", the main difference being in colour of the rind and sweetness. Mithi fruit is particularly acidless and its sugar contents are sufficiently high whereas "Jamberi" fruit has got very high acid content and very low sugars. Mithi, therefore, is positively a sweet variety of the lemon, species Citrus limon. These findings corroborate with those of Webber (1943) who has described sweet varieties not only in lemons but also in the citrus species C-Medica.

Jullundri Khatti. This also appears to be variety of lemons. With the exception of o shape and surface of fruit, all characters of "Jullundri Khatti" resemble with those of "Jatti Khatti". The fruit is, however, smooth skinned and round in shape. It may, therefore, be called smooth lemon vis-a-vis "Jatti Khatti" which is known as rough lemon. Jullundri Khatti is, therefore, a variety of lemon species *C. limon*.

Khatta. Khatta fruit is also known as kimb in some districts of the Punjab and seville kimb at Renala Khurd, Punjab. Its English synonym is sour or seville orange, the commonly accepted name is *Citrus aurantium* Linn: But *C. vulgaris* Risso and *C. bigardia* Risso Poiteaet have also been used. All other names have been discarded in favour of *C. aurantium.* The morphological characters are characteristic of the species and do not require to be mentioned here.

Gada Dehi. This rootstock under trial at the H.R.S.S., Montgomery was imported from Ceylon. No reference of this fruit or similar fruit has been found in any of the available literature. It is a large tree with compact head. Shoots, leaves and flowers are similar to those of Khatta or sour orange. The leaves of "Gada Dehi" are, however, somewhat larger in size. The main difference is found in fruit which is rounded-oblate in shape and is smooth skinned as compared with the Khatta fruit, the surface of which is coarsely papillated and rough. Rind of "Gada Dehi" fruit is thin whereas that of Khatta is medium thick. Gada Dehi fruit is comparatively more juicy. Both Gada Dehi and sour orange fruits are sour to taste.

The seeds are almost identical in shape and size. Whatever minor differences are noted between the two fruits may be considered as varietal only in magnitude. Gada Dehi, therefore, should be considered as variety of sour orange, species *C. aurantium.*

Webber (1943) has described 10 varieties of the sour orange cultivated in the U. States, and besides mentioning differences in size, shape, form and surface of the fruit he mentioned about the great amount of variation in the tree size, thorniness of the branches and shape of the leaves. The above results, therefore, corroborate his observations.

Nasnaran. Nasnaran is another citrus fruit imported from Ceylon, for trials as rootstock. It has been described as *Citrus Japanica Thumb* but this does not seem to be correct. *Citrus Japonica Thumb* is the name assigned by some workers to Fortunella Japanica (Thumb) Swing, round Kumquat, a species of the subgenus Eufortunella. The taxanomy of the Nasnaran tree, as described by Haq (1952), takes it close to the limes species *Citrus aurantifolia* (christm) Swing. Minor differences in the fruit may be considered as varietal only.

STUDY OF ROOT SYSTEM OF SOME OF THE ROOTSTOCK VARIETIES

A study of the root system of some of the stock varieties raised both from seeds and cuttings was made at the time of budding. The plants were lifted very carefully with all roots intact, counts and measurements of lateral and vertical roots were made in each case. Besides this, such points as the zone of distribution of lateral roots, maximum depth reached by the vertical roots were also studied. Counts of the total leaf area and number of branches in the aerial portion at the time of budding were also made. The data pertaining to these studies are embodied in the Tables 3 & 4 on next page.

Two plants of each of the varieties employed in rootstock investigations were lifted for examination of roots. The soil when material was grown was classed as light loam. There was nearly as much difference between the two individuals belonging to one variety as probably there is between the varieties in each set. It was, therefore, considered safe to present data on the basis of single plant study of rootsystem of each rootstock rather than present the same as average of two individuals. Notwithstanding the limitations of such an investigation which, if done on an elaborate scale, consumes considerable amount of time, two figures in Tables 3rd & 4th offer in a general way some interesting observations as under :

(*a*) **Lateral roots.**—(*i*) There is little difference between maximum expansion of lateral roots of the rootstocks in sets A and B.

(*ii*) The number of lateral roots and their "zone of distribution" is comparatively larger in set A than in set B.

(*iii*) In set A the rootstock has tendency to throw out lateral roots right from the surface level but in set B some of the root stocks do not throw out such roots till a distance of 0-20 cms. from the surface is reached.

(*b*) **Vertical roots.**—(*i*) The number of vertical roots in case of rootstocks in set A is much larger than in case of the same rootstocks in set B.

(*ii*) The depth reached by the rootstocks is 2-3 times the depth reached by the same rootstocks in set B.

The vigour productivity quality etc., of various cultivated species of citrus as influenced by rootstocks grown from seed and cutting.

As a result of extensive work carried out in several countries on the influence of rootstocks on various scion varieties, it has been proved that the rootstocks profoundly influence the scions budded or grafted on them. In order, therefore, to study the effect of various stocks grown in our country, necessary plant material was raised and planted at the Horticultural Research Sub-Station, Montgomery in February, 1937. Four scion varieties, namely malta common (*C. sinensis*) Malta Blood Red, Grape fruit Marsh seedless (*Citrus paradisi*) and sangtra local (*C. nobilis*), were budded on to each of the several rootstock varieties propagated both from seeds and cuttings. Although the preparation of genetically

TABLE 3

Showing the root character, at the time of budding of various rootstocks (set A propagated from seed) under trial

Rootstocks under study	Lateral Roots			Vertical Roots			No. of Aerial Shoots and Leaf Area
	Maximum expansion in cm	No. of lateral roots	Zone of distribution cms	Number	Maximum depth reached cm	Average depth reached cm	Leaf Area in Sq. Cms
No. 20 Jatti Khatti ...	176	33	0-56	9	178	174	2 main shoots and 21 small shoots.
,, 50 Mitha ...	240	16	0-36	2	250	250	3 main and 16 branches 30382.
,, 47 Chakotra ...	220	14	0-80	4 (all fine)	160	120	One main 13 very thin 16445.
,, 1 Jatti Khatti ...	200	11	0-36	1 ,,	204	204	3 main, 35 fine shoots 32560.
,, 43 Kharna Khatta...	200	27	0-48	9	192	190	2 main 28 fine 57350.
,, 9 Mokari ...	260	22	0-100	10	180	175	3 main 15 small 42525.
,, 44 Jatti Khatti ...	280	17	0-68	6	180	175	2 main 40 secondary 37518.

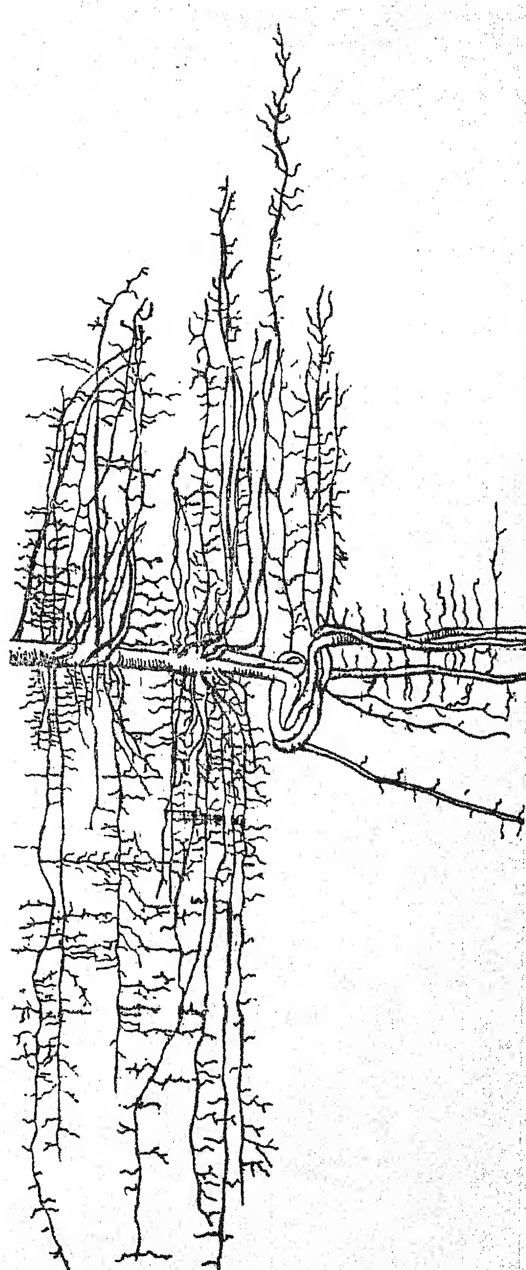
TABLE 4

Showing the root character at the time of budding, of the various rootstocks (set B propagated by the rooting of stem-cutting) under trial.

Rootstocks under study	Lateral Roots			Vertical Roots			No. of Aerial Shoots and Leaf Area
	Maximum expansion in cm	No. of lateral roots	Zone of distribution cms	Number	Maximum depth reached cm	Average depth reached cm	Leaf Area in Sq. Cms
No. 20 Jatti Khatti ...	256	11	0-32	1	64	64	...
,, 50 Mitha ...	272	10	12-24	Nil*	32	32	...
,, 9 Mokari ...	256	12	4-44	Nil*	44	44	...
,, 43 Kharna Khatta ...	248	8	0-36	2	160	160	...
,, 1 Jatti Khatti ...	260	3	20-48	Nil*	48	48	...
,, 2 Jullundri Khatti...	200	6	12-40	Nil*	40	40	...
,, 38 Jatti Khatti ...	306	23	0-44	1	84	84	...
,, 10 Mokari R. K. ...	220	5	8-76	1	80	80	...
,, 11 Kharna Khatta...	116	30	0-60	3	84	76	...
,, 6 Mitha ...	128	7	0-20	1	32	32	...

*(Fine rootlets arising out of lateral but going in vertical direction were measured).

Note.—The age of plants at the time of root study was two years in both the sets.



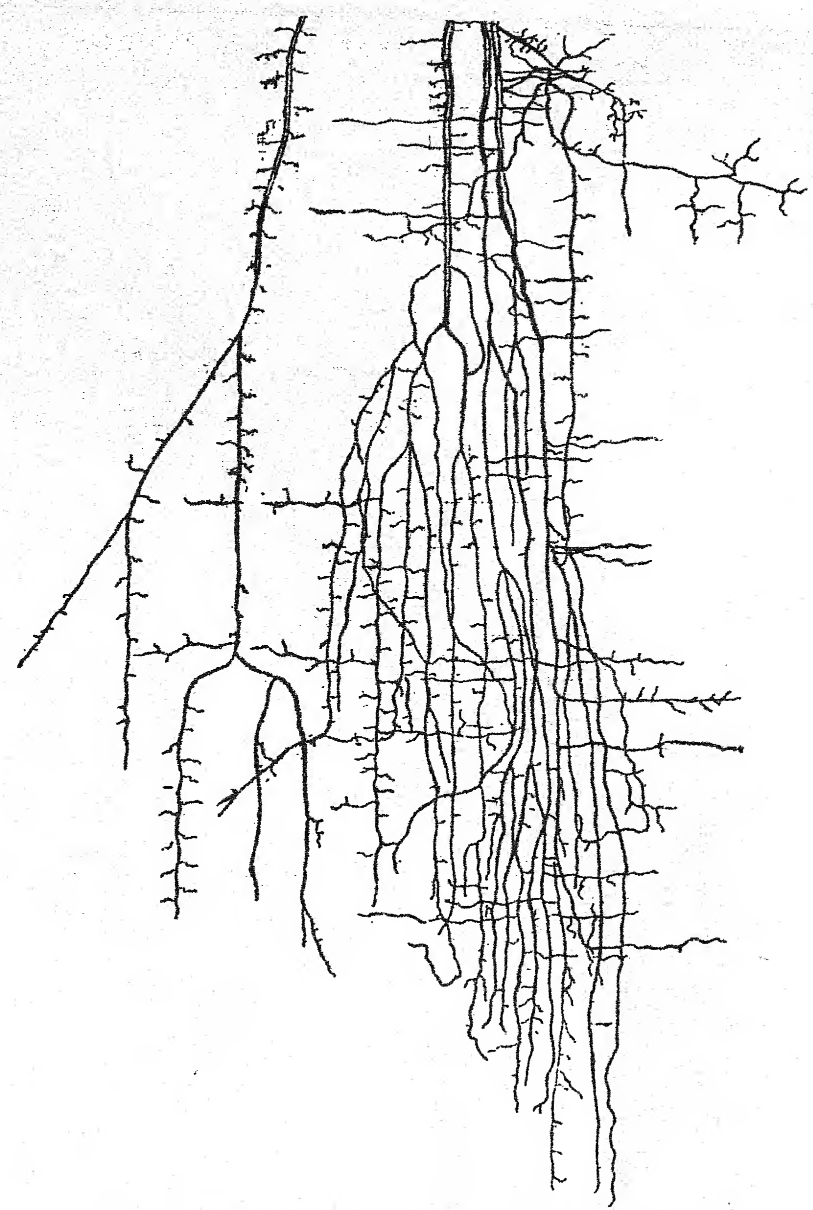


Fig. 2.—CHAKOTRA No. 47 (SHAHDARA)—Raised from Seed.

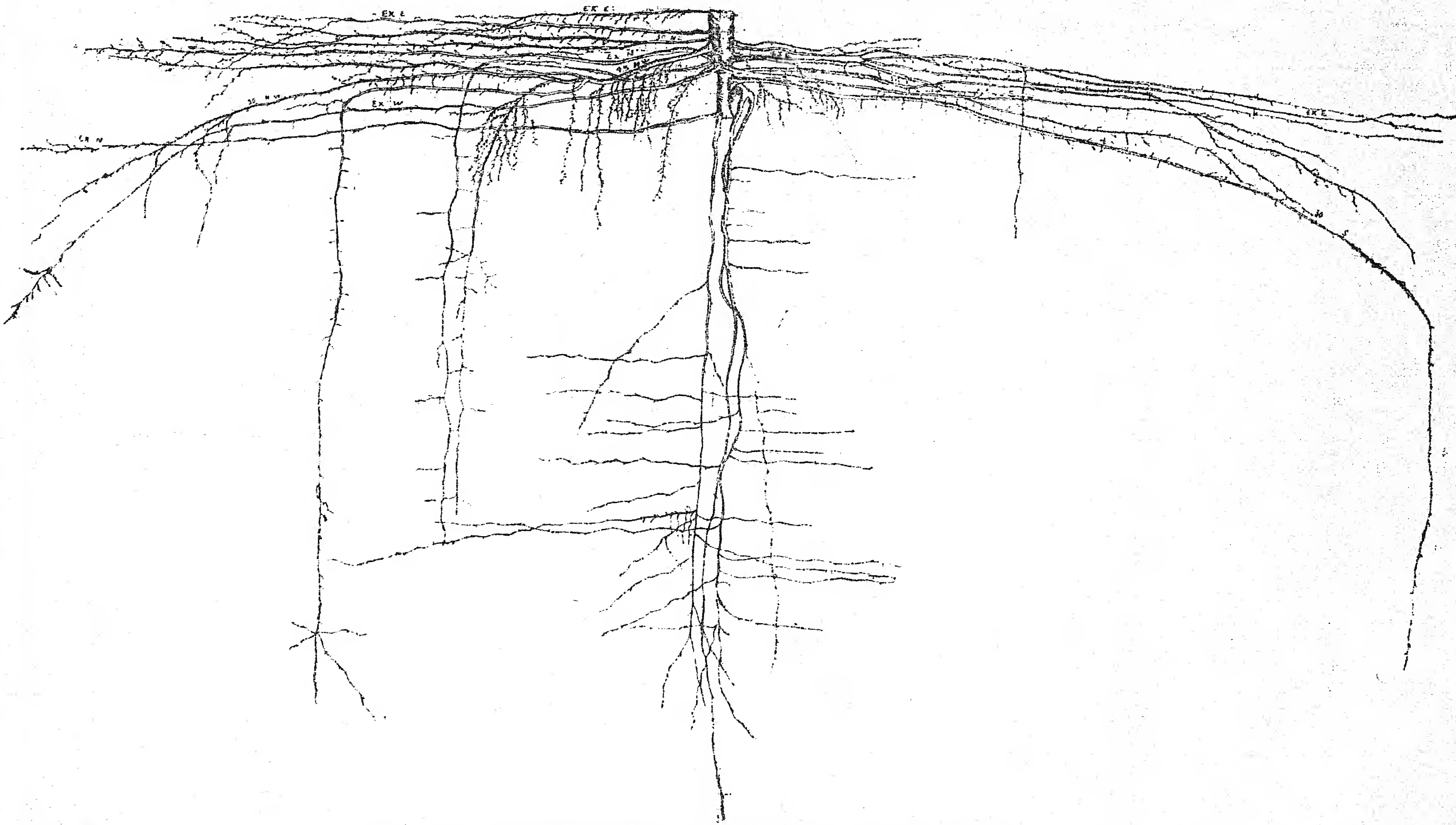


Fig. 3.—JATTI KHATTI No. 44 (SHAHDARA)—Raised from Seed.

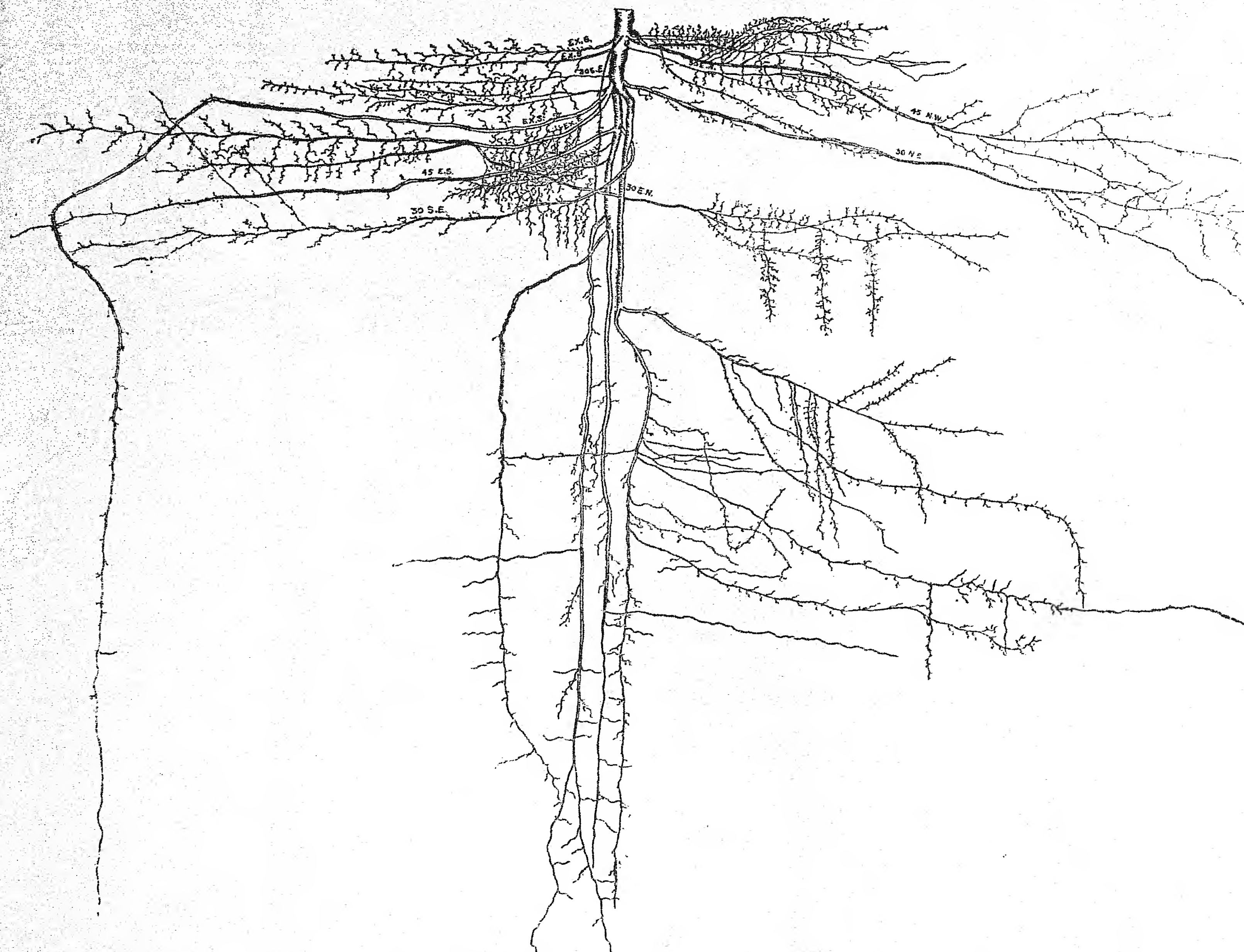


Fig. 4.—KHARNA KHATTA No. 43 (SHAHDARA)—Raised from Seed.

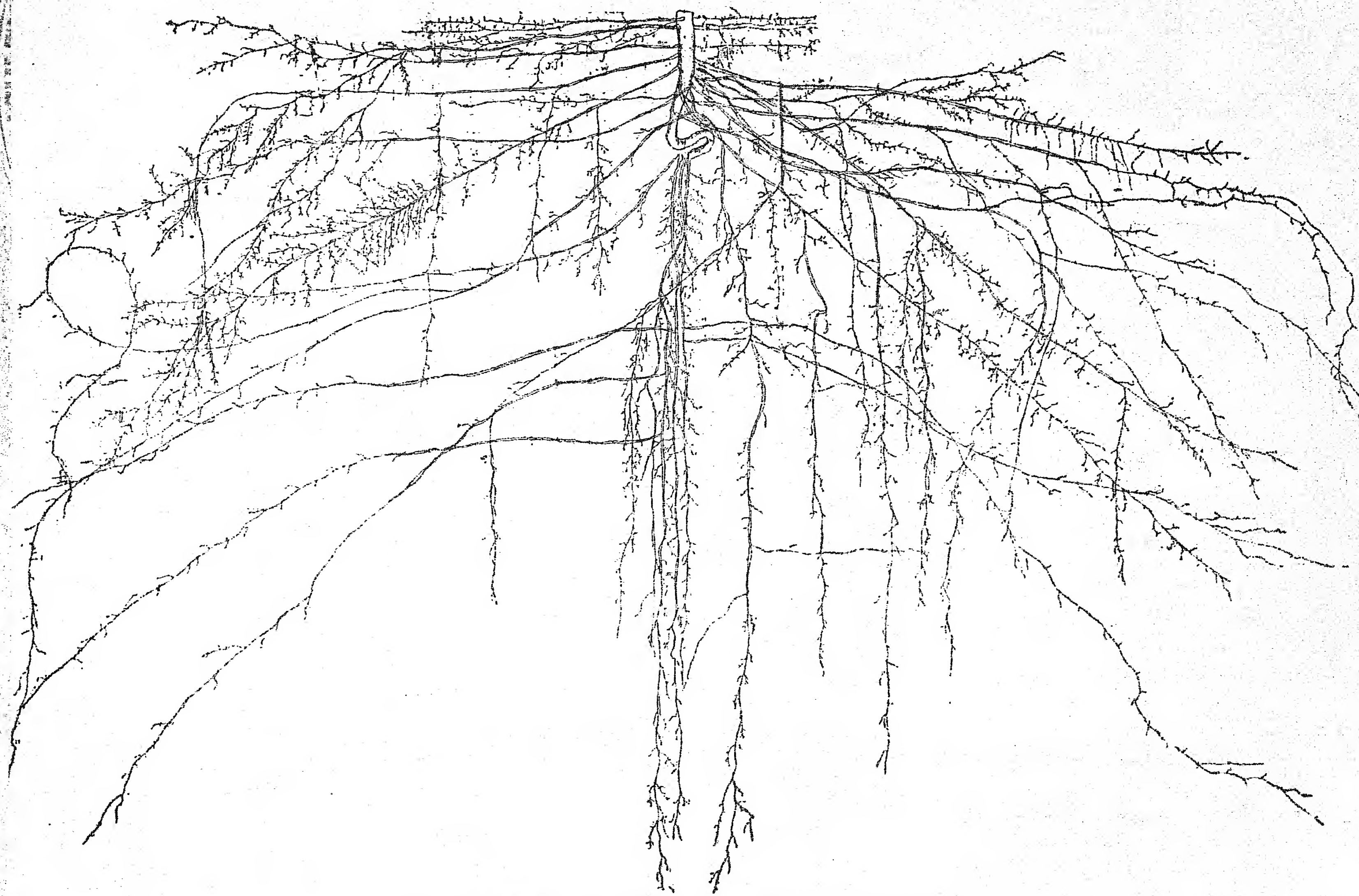


Fig. 5.—MOKARI No. 9 (RENALA KHURD)—Raised from Seed.

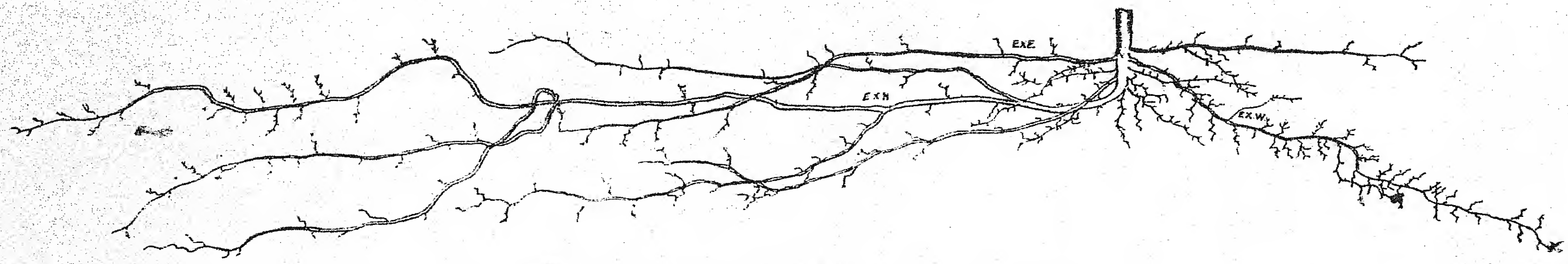


Fig. 6.—MOKARI No. 9 (RENALA KHURD)—Propagated Vegetatively.

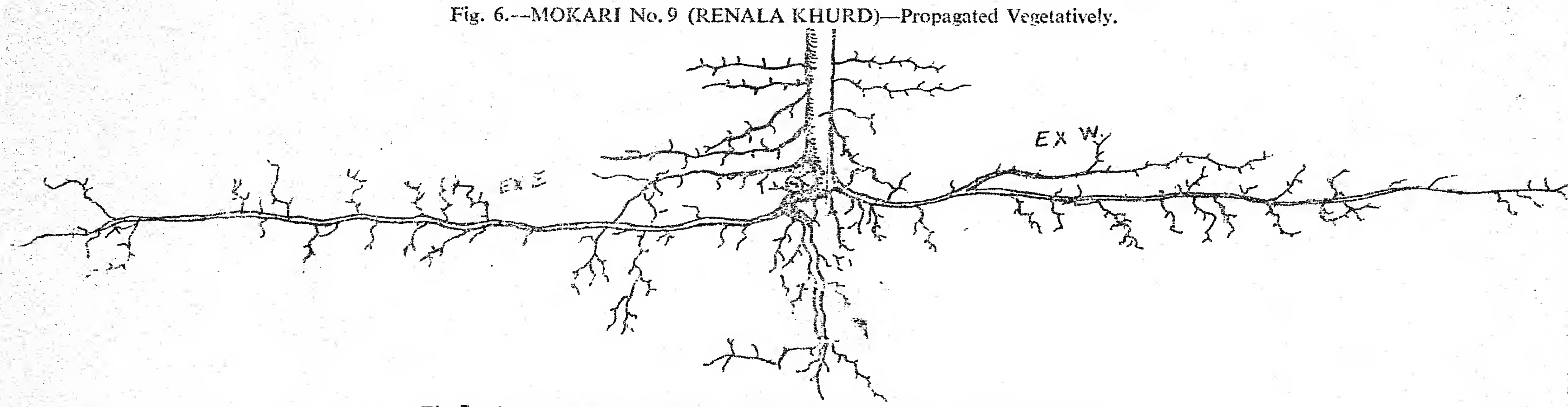


Fig. 7.—SWEET LIME (RENALA KHURD) No. 6.—Propagated Vegetatively.

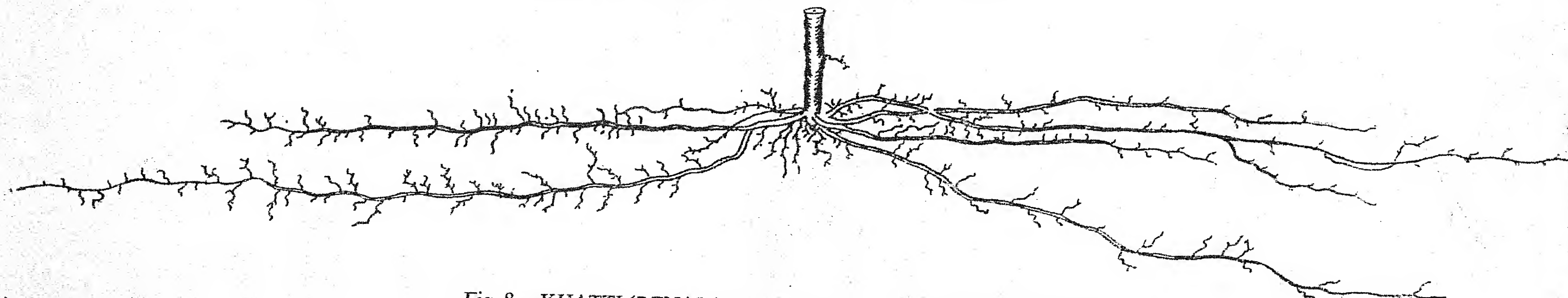


Fig. 8.—KHATTI (RENALA KHURD) No. 2.—Propagated Vegetatively.

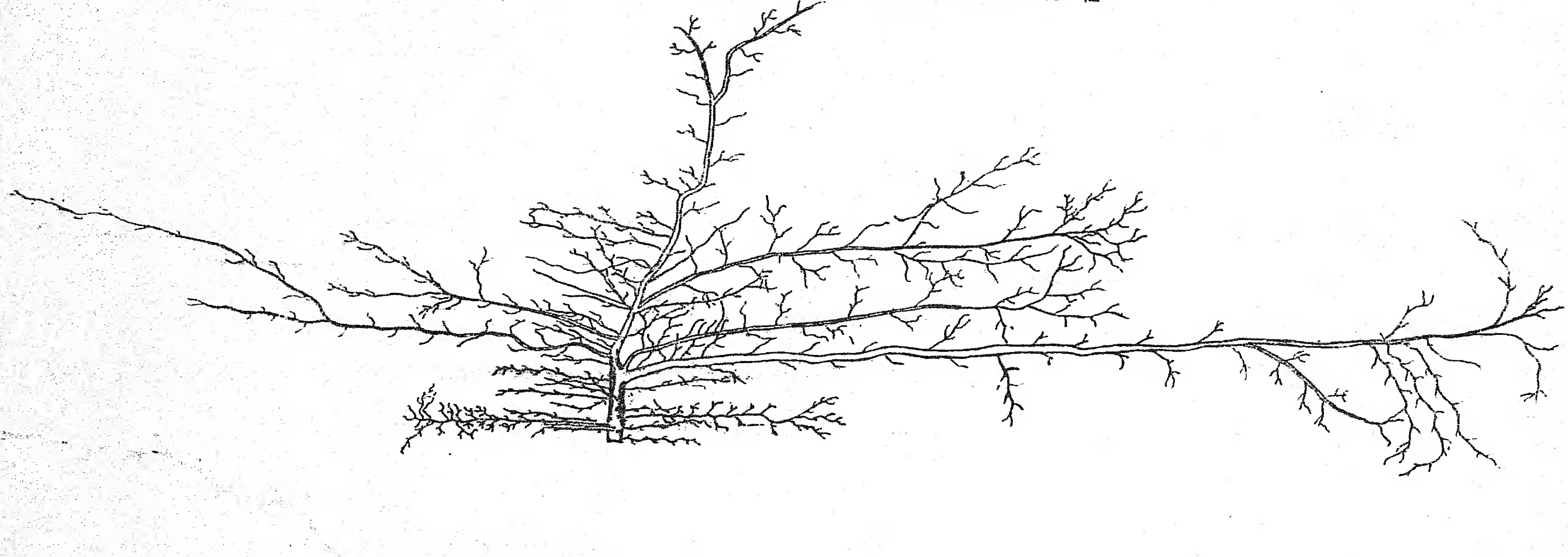


Fig. 10.—KHATTI No. 38 (SHAHDARA)—Propagated Vegetatively.

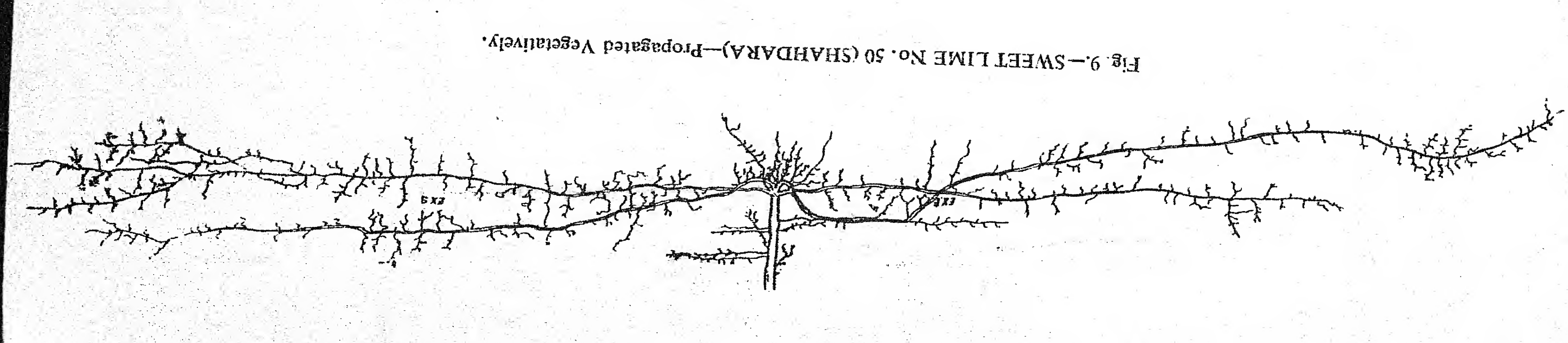


Fig. 9.—SWEET LIME No. 50 (SHAHDARA)—Propagated Vegetatively.

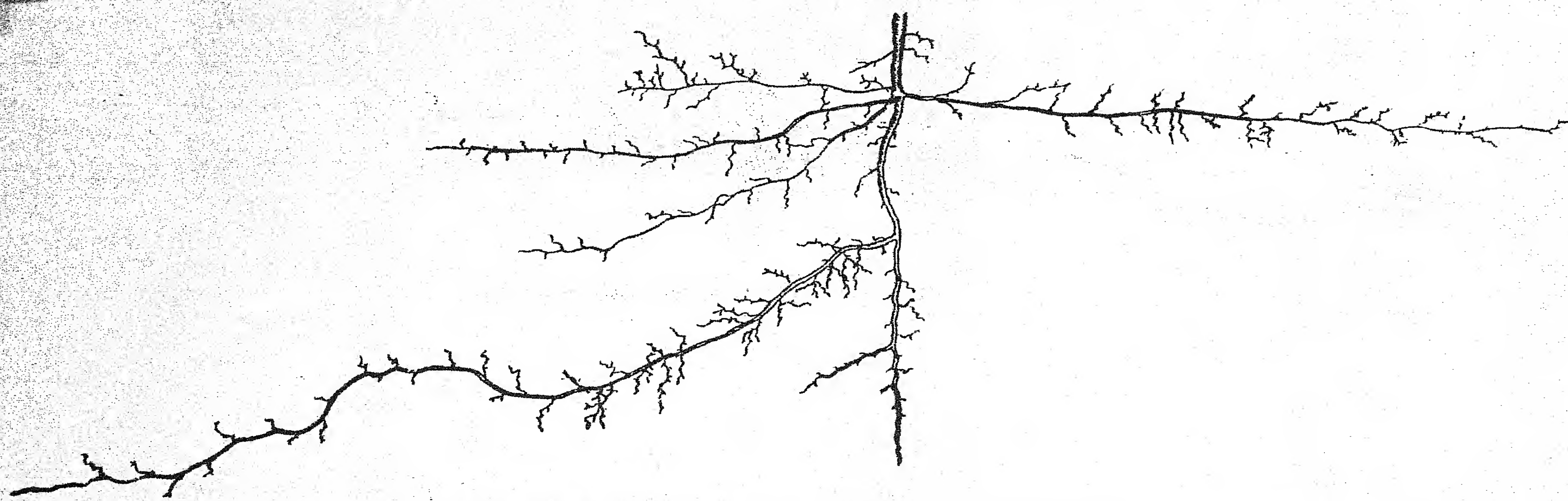


Fig. 11.—MOKARI No. 10 (RENALA KHURD).—Propagated Vegetatively.

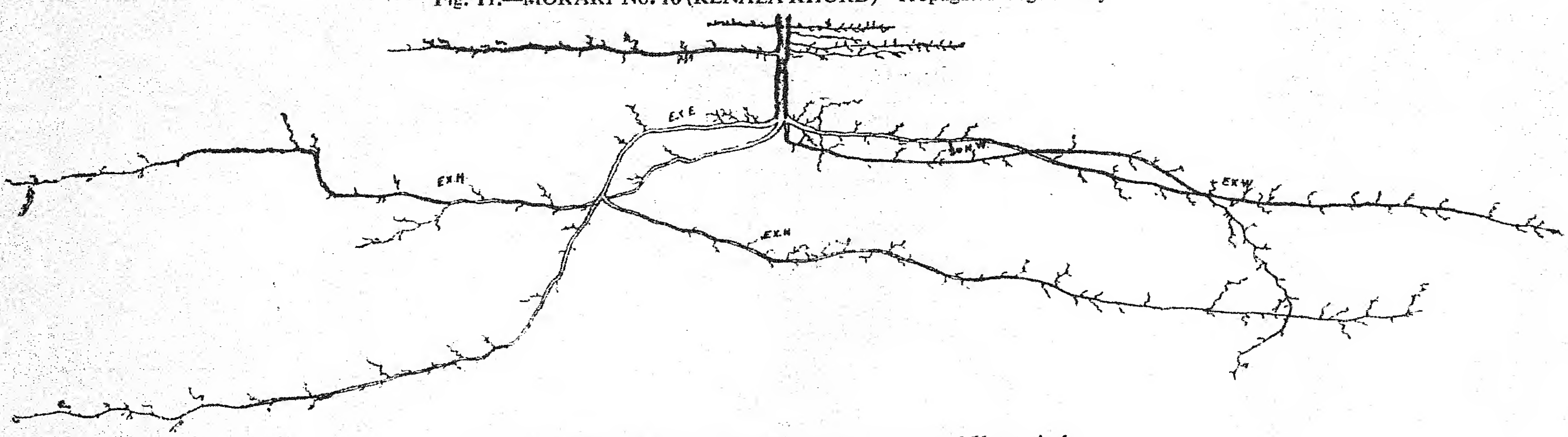
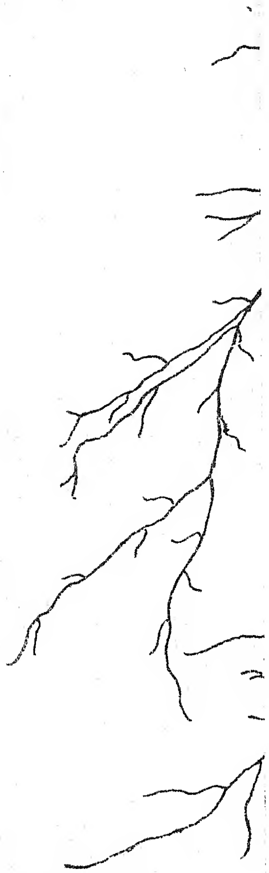


Fig. 12.—KHATTI No. 20 (LYALLPUR).—Propagated Vegetatively.



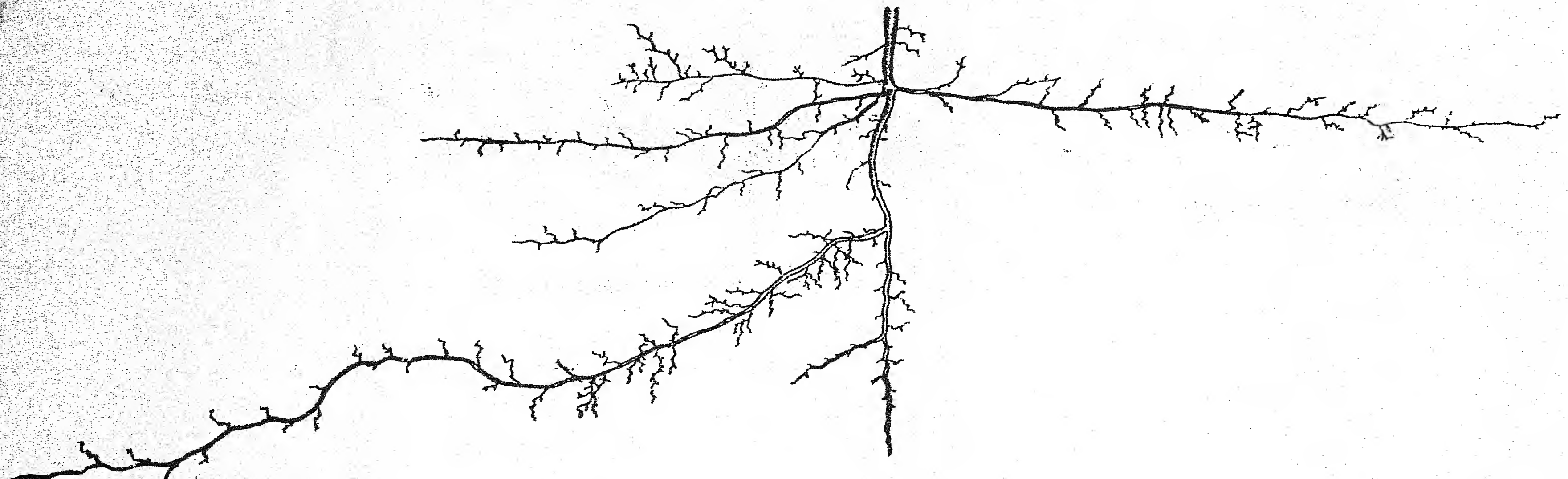


Fig. 11.—MOKARI No. 10 (RENALA KHURD)—Propagated Vegetatively.

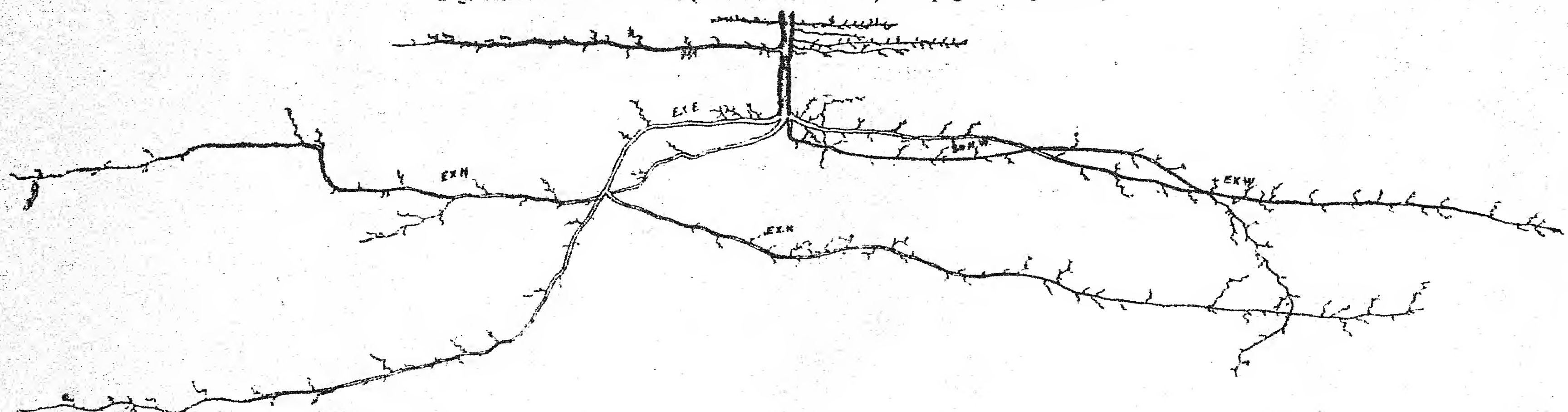


Fig. 12.—KHATTI No. 20 (LYALLPUR)—Propagated Vegetatively.

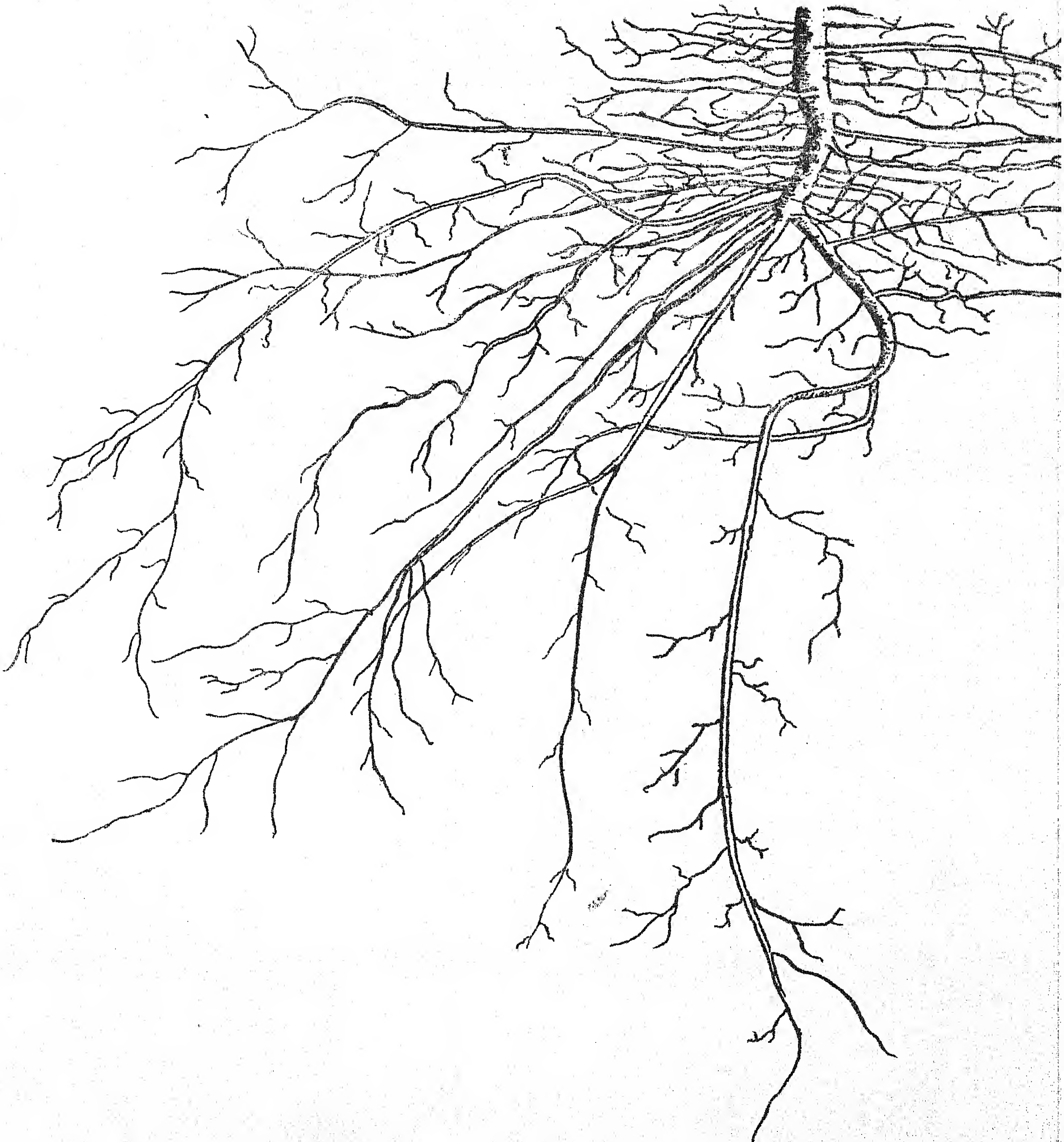


Fig. 13.—KHARNA KHATTA No. 11 (LYALLPUR)—Propagated Vegetatively

identical material could have been advantageously effected by placing scion buds gathered from single parent tree on to carefully selected apogamic seedlings, yet the use of clonal material was also employed in addition to seek answers to such questions of practical and economic importance to apogamic seedlings as (*a*) will the vegetatively propagated rootstocks differ from the apogamic seedlings notwithstanding the similarity of their genetic build-up, in their influence on the scion variety? (*b*) How will the coefficients of variability in the two sets of material determined at planting time, compare later in the life history of the experiment with regard to the vigour and cropping of the scions?

In particular the utility of the various rootstocks for malta, sangtra and grape fruit would be determined by investigations as to the influence of rootstocks on scions regarding (*a*) growth and vigour (*b*) productivity (*c*) fruit quality, (*d*) resistance to diseases and (*e*) longevity. Answers to such questions would go a long way to place the citrus industry of the province on a sound footing.

Description of the material.—As stated before, the experimental material broadly consists of two sets of groups. In the one set four scion varieties are budded on the several rootstocks raised from seed; in the other set the same four scion varieties are budded on to vegetatively propagated rootstocks. With a few exceptions the rootstock varieties of the experimental material are also the same in both the sets. For convenience of reference these sets would be designated as set A and set B. Set A constitutes the four rootstock scion groups prepared by budding four scion varieties on several rootstocks propagated from seed, and set B includes the other four groups prepared by budding the same four scion varieties on the rootstocks that were propagated by vegetative means. The specifying numbers allotted to the rootstocks in both sets of groups are purely arbitrary, and are not based on any systematic study.

The material in sets A & B were planted on the left and right hand sides respectively of the central roads of the plantation (Fig. 14). In this figure the arrangements of plots, position of main channels and block channels and position of paths etc., are shown.

Layout.—The 'Randomised Block Method' being most adaptable to field experiment in horticulture, is the one here adopted to the exclusion of any other. The arrangement and distribution of different rootstock scion combination within the plots is explained in Fig. 15.

Each plot is divided into six blocks so that six replications are maintained in case of each combination. Each block, in turn, is divided into as many sub-blocks as is the number of rootstock varieties to be compared. The dimensions of the size of sub-block vary from 20'×60' to 20'×80' depending upon the No. of plants in each case is three or four. In other words, a unit of three to four plants of any particular rootstock scion combination is replicated six times, so that there are 18-24 plants of this in any one plot.

The planting of all the eight plots, follows the square system of planting, and a uniform distance of 20 feet to keep both from plant to plant and row to row.

The arrangement of main channel and plot channels, with respect to the position of rootstock scion combinations within any-one block, is such as to distribute evenly the variable effects of water due to seepage over all the rootstock scion combinations under trial. Non-experimental rows have also been provided wherever necessary.

Irrigation, cultural treatments as well as tntercropping were uniform for all the treatments in each plot.

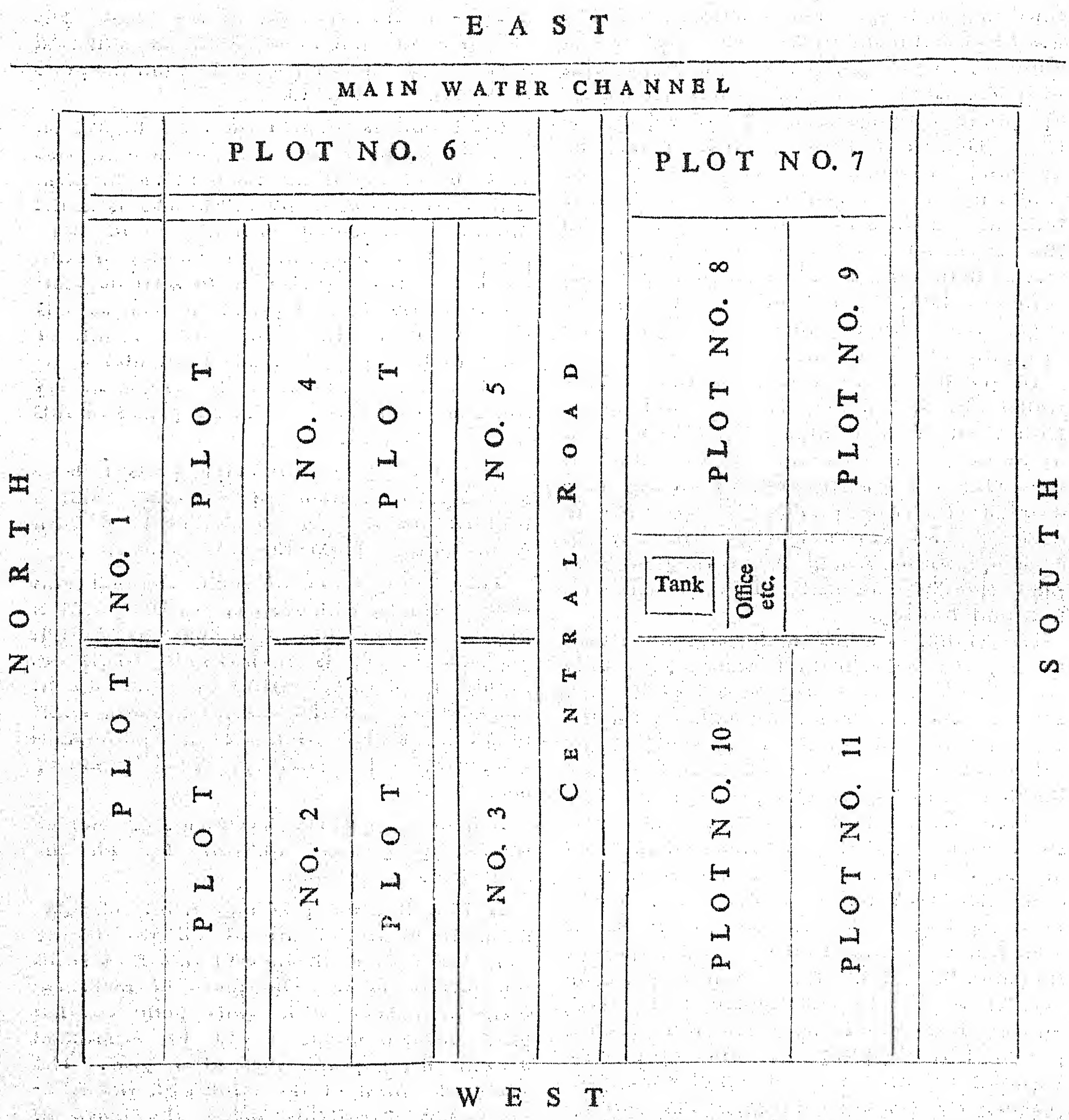
A month after planting, trunk circumferential measurements of all the plants were taken at a distance of one foot from the surface level. The place of measurement is marked with white paint so that girth measurements could be continued at one fixed point year after year. The place of union of the scion with the rootstock fell invariably below the place of measurement.

In the succeeding paragraphs, detailed discussion on various tree and fruit characters as influenced by various rootstocks will follow for all the experiments.

Data were recorded on the following points:—

(*a*) Girth, (*b*) Spread, (*c*) Height, (*d*) Yield (*e*) Quality, (*i*) Size of fruit, (*ii*) Percentage

LAYOUT PLAN OF HORTICULTURAL RESEARCH SUBSTATION, MONTGOMERY

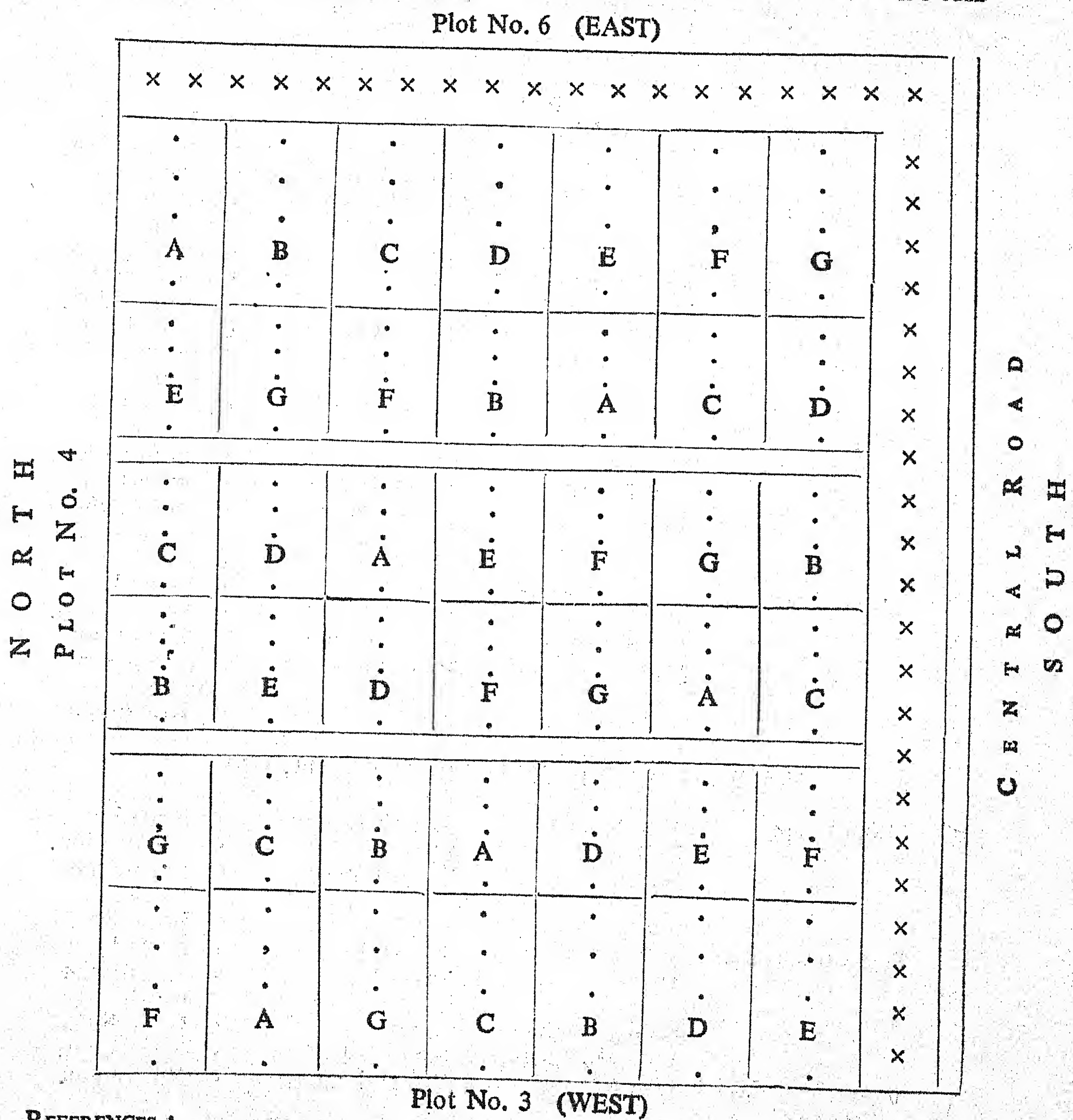


REFERENCES

Plot No. 1.	Rootstock Block		Plot No. 6.	Grapes Block	
,, No. 2.	Sangtara Local	Rootstocks raised from seed.	,, No. 7.	Nursery Area	
,, No. 3.	Malta Blood Red		,, No. 8.	Sangtara Local	Rootstocks raised by the rooting of stem cuttings
,, No. 4.	Marsh Seedless		,, No. 9.	Marsh Seedless	
,, No. 5.	Malta Common		,, No. 10.	Malta Common	
			,, No. 11.	Malta Blood Red	

Fig. 14

LAYOUT PLAN OF PLOT NO. 5 SHOWING THE DISTRIBUTION OF SEVEN DIFFERENT ROOTSTOCK SCION COMBINATIONS IN SIX BLOCKS



REFERENCES :

A—Malta common on Rootstock No. 20
B—......................do...................... 9
C—......................do......................21
D—......................do...................... 1
E—......................do......................43
F—......................do......................44
G—......................do......................50

Fig. 15

The various rootstocks, scion combinations in sets A and B are tabulated below:—

Plot No.	Name of scion. Set A (Stocks raised from seed)	Name of stock	Possible English Name	Specific Name
		SET A		
5	Malta Local	Kharna Khatta	Nil	*C. karna* Raf.
	do.	Mokari	Citron	*C. medica* Linn.
	do.	Jatti Khatti	Rough Lemon	*C. limon* Linn.
	do.	Mitha	Sweet Lime	*C. aurantifolia* Swingle.
	do.	Nasnaran	Nil	*C. aurantifolia*
3	Malta Blood Red	Kharna Khatta	Nil	*C. karna* Raf.
	do.	Mokari	Citron	*C. medica* Linn.
	do.	Jatti Khatti	Rough Lemon	*C. limon* Linn.
	do.	Mitha	Sweet Lime	*C. aurantifolia* Swingle.
4	Grape Fruit Marsh Seedless	Kharna Khatta	Nil	*C. karna* Raf.
	do.	Mokari	Citron	*C. medica* Linn.
	do.	Jatti Khatti	Rough Lemon	*C. limon* Linn.
	do.	Mitha	Sweet Lime	*C. aurantifolia* Swingle.
	do.	Chakotra	Shaddock	*C. grandis* linn.
2	Sangtra Local	Kharna Khatta	Nil	*C. karna* Raf.
	do.	Mokari	Citron	*C. medica* Linn.
	do.	Jatti Khatti	Rough Lemon	*C. limon* Linn.
	do.	Mitha	Sweet Lime	*C. aurantifolia* Swingle.
	do.	Nasnaran	Nil	*C. aurantifolia*
		SET B (STOCKS RAISED FROM CUTTINGS).		
10	Malta Local	Jatti Khatti	Rough Lemon	*C. limon* Linn.
	do.	Mokari	Citron	*C. medica* Linn.
	do.	Mitha	Sweet Lime	*C. aurantifolia* Swingle.
	do.	Kharna Khatta	Nil	*C. karna* Raf.
11	Malta Blood Red	Jatti Khatti	Rough Lemon	*C. limon* Linn.
	do.	Mitha	Sweet Lime	*C. aurantifolia* Swingle.
	do.	Kharna Khatta	Nil	*C. karna* Raf.
	do.	Jullunduri Khatti	Smooth Lemon	*C. limon* Linn.
9	Grape Fruit Marsh Seedless	Jatti Khatti	Rough Lemon	*C. limon* Linn.
	do.	Mitha	Sweet Lime	*C. aurantifolia* Swingle.
	do.	Mokari	Citron	*C. medica* Linn.
	do.	Kharna Khatta	Nil	*C. karna* Raf.
8	Sangtra Local	Jatti Khatti	Rough Lemon	*C. limon* Linn.
	do.	Mitha	Sweet Lime	*C. aurantifelia* Swingle.
	do.	Mokari	Citron	*C. medica* Linn.
	do.	Kharna Khatta	Nil	*C. karna* Raf.

of juice, (*iii*) Percentage of peel and rag, (*iv*) Total Soluble Solids, (*v*) Acidity, (*f*) Longevity.

I (A). **Influence of different rootstocks on Sangtra local scion variety (Rootstocks raised from seed).**

(*a*) **Vigour.**—The influence of rootstcoks on the vigour of the trees is indicated by the increase in stem girth, measured at a fixed point above the union of stock and scion.

In the prebearing age "Kharna Khatta" was leading all the stocks in its outstanding character of invigorating trees, but "Nasnaran" stole a march over this stock in the later years. "Nasnaran" is thus associated with most vigorous trees of Sangtra local followed by "Kharna Khatta". "Jatti Khatti" is a mediocre for this scion variety. "Mokari" and "Mitha" have been noted for inducing least vigour in case of sangtra local. It may be interesting to note that both "Mokari" and "Mitha" produced trees taller than "Jatti Khatti" but in spread inducing character "Jatti Khatti" leads "Mokari" and is placed next to "Mitha" in this character.

(*b*) **Cropping.**—Mokari induced much better cropping than all the rootstocks under trial. It is followed by "Nasnaran", "Mitha", "Kharna Khatta" and "Jatti Khatti" in order of sequence. Nasnaran and Mitha are not significantly different from each other in cropping.

(*c*) **Quality.**—The price of fruit in the market depends on its quality. It is a matter of common knowledge that Malta orange fruit which has red pulp is preferred over others, whereas in the case of grape-fruit, coloured pulp is not preferred, but within these groups also there is much variation in price. The greatest attention is paid to external characters of the fruit in the market. Small to medium sized smoother skinned fruits are sold at a premium, whereas there is little demand for very big sized and rough skinned fruits. Percentage of juice, peel, rag etc., as well as total soluble solids and acidity, are other important characters that determine quality in a certain case.

In the following paragraphs all these characters will be discussed separately under proper heads.

(*i*) *Size of fruit.*—"Mitha" and "Mokari" have produced slightly bigger sized fruits, but these are not significantly different from others under trial. "Mokari" is the worst stock in this aspect also. The remaining stocks may be taken to have produced fruit of the desirable size and texture.

(*ii*) *Percentage of Juice.*—The juice content was increased significantly by "Jatti Khatti" as compared with other stocks. It is followed by "Mitha," "Nasnaran", "Kharna Khatta" and "Mokari" in the descending order. "Nasnaran" and "Mitha" are not significantly different from each other as far as juice contents are concerned. "Mokari" is associated with the production of least juicy fruits of Sangtra local.

(*iii*) *Percentage of peel and rag.*—"Mitha" and "Mokari" which increased the size of the fruit also increased the percentage of peel and rag. Of these two, "Mokari" induced a higher percentage of peel than "Mitha". The remaining rootstocks produced fruit with least amount of peel and rag.

(*iv*) *Total soluble solids.*—The sugar contents of the juice are mainly responsible for the quality of the fruit. Even if the fruit may have all other desirable characters and high percentage of juice yet if sugar percentage is too low, the fruit will not be liked.

Nasnaran induces highest percentage of total soluble solids followed by "Mitha", "Jatti Khatti" and "Kharna Khatta" in descending order. "Mokari" is associated with fruit production of low sugar contents.

(*v*) *Percentage of acidity.*—The slight amount of acidity in the fruit of a given variety is as desirable as the adequate amount of sugar present therein. In fact it is the proper blend of sugar and acidity that determines quality. If in a certain case high percentages of sugar is associated with low acidity then the taste of the fruit will be insipid. Similar will be the case where the sugar percentage is low and acidity high.

"Nasnaran" and "Jatti Khatti" have induced highest percentage of acidity followed by sweet lime. "Mokari" and "Kharna Khatta" come next.

While considering the proper sugar acid blend, "Nasnaran" will be placed at the

top, followed by "Jatti Khatti" and "Mitha". "Mokari" produces the most inferior quality fruit in case of Sangtra local.

(*d*) **Longevity.**—Plants of Sangtra local on "Mokari" and "Mitha" arenot long-lived. All the other stocks are very good as far as longevity is concerned.

General conclusions.—"N a s n a r a n", "Mitha", "Mokari" and "Kharna Khatta" are good stocks as regards yields, but quality of fruit is poor in case of plants budded on "Mokari". Therefore considering all the important points "Nasnaran", "Kharna Khatta" and "Sweet lime" can be recommended as suitable stocks for Sangtra local.

I (B) Influence of different rootstocks on Sangtra local (Rootstocks raised by cuttings).

(*a*) **Vigour.**—"Kharna Khatta" is associated with plants of maximum vigour followed by Jatti Khatti. "Mokari" and "Mitha" come next in order of merit. Although "Mokari" is associated with slightly more vigorous plants of Sangtra local as compared to those on "Mitha", the height of trees raised on "Mitha" stock is more than those raised on "Mokari".

Although plants raised by cuttings produced bigger sized trees much earlier but eventually trees raised by seed accelerated their growth and got bracketed with those raised by cuttings.

(*b*) **Cropping.**—In this case also "Mokari" is associated with highest yields, followed in a descending order by "Kharna Khatta" "sweet lime" and "Jatti Khatti".

(*c*) **Quality.**—(*i*) *Size of fruit.*—"Mokari" produced bigger sized fruits followed by "Mitha". The size of fruit in other cases was medium.

(*ii*) *Percentage juice contents.*—"Jatti Khatti" has induced maximum percentage of juice followed by "Mitha", "Kharna Khatta" and "Mokari" in order of sequence.

(*iii*) *Percentage of peel and rag.*—Excepting "Mokari", other stocks did not induce peel and rag percentages significantly different from each other. "Mokari" produced fluffy oversized fruits with rough outer rind.

(*iv*) *Percentage of total soluble solids.*—"Sweet Lime" leads all other stocks and is followed by "Jatti Khatti" and "Kharana Khatta" in a descending order. "Mokari" is associated with fruits of lowest sugar contents.

(*v*) *Percentage acidity.*—"Mitha" and "Jatti Khatti" rootstocks are associated with correspondingly high acidity and thus they are the best rootstocks as far as characters constituting the quality of fruit are concerned.

(*d*) **Longevity.**—The points already discussed under Sangtra local raised by seed, hold good in this set of experiment also.

General conclusions.—"Kharna Khatta" and "Sweet Lime" are best rootstocks, for Sangtra local variety. "Jatti Khatti" produces fruit of high juice content but the gap in the yield between "Kharna Khatta", and "Jatti Khatti" is so great that a recommendation in favour of former stock becomes irresistible.

II (A). Influence of different rootstocks on Malta local (Rootstocks raised by seed).

(*a*) **Vigour.**—In this case also "Nasnaran" takes a lead over all other stocks, in the prebearing age; however, "Kharna Khatta" used to lead all the stocks, but gradually the rate of growth in case of "Nasnaran" was much accelerated and it excelled all the stocks under trial. It is followed by "Kharna Khatta" and "Jatti Khatti" which are bracketed as far as vigour inducing character is concerned. "Mitha" and "Mokari" are conspicuously dwarfing stocks, "Mokari" is the worst in this character also.

(*b*) **Cropping.**—"Kharna Khatta" produced most prolific plants, followed in order of merit by "Nasnaran", "Jatti Khatti", "Mitha" and "Mokari". Considering the yield inducing character of these stocks, only "Kharna Khatta" and "Nasnaran" can be safely recommended "Mokari" and "Mitha" are the most uncongenial stocks for malta local variety. "Jatti Khatti" is only a mediocre.

(*c*) **Quality.**—(*i*) *Size of fruit.*—"Mitha" and "Mokari" both significantly increased the size of fruits in case of Malta local, thereby deteriorating the marketing quality of fruit in this case. The remaining root-

stocks behaved almost alike in influencing the size of the fruit of scion under study.

(*ii*) *Percentage of juice.*—"Nasnaran" induced the maximum percentage of juice followed by "sweet lime", "Jatti Khatti" "Kharna Khatta" and "Mokari" in order of sequence. "Mokari" produced fruit with the least juice contents.

(*iii*) *Percentage of peel and rag.*—"Mitha" and "Mokari" which sufficiently increased the size of the fruit, also increased the percentage of peel and rag. Of these two, "Mokari" induced a higher percentage of peel and rag than "Mitha".

(*iv*) *Percentage of total soluble solids.*—"Kharna Khatta" is associated with juice contents of higher T. S. S. than all the others. It is followed by "Nasnaran" and "Mitha", "Jatti Khatti" comes next but produces higher T. S. S. as compared to "Mokari", which is at the lowest ebb in the sugar inducing character as well.

(*v*) *Percentage of acidity.*—"Kharna Khatta" produces highest percentage followed by "Mitha, " "Jatti Khatti", "Mokari" and "Nasnaran". "KharnaKhatta", "Mitha" "Nasnaran" and "Jatti Khatti" induce a proper blend of acidity and sugar.

(*d*) **Longevity.**—"Mitha" and "Mokari" decline quickly and are not useful stocks for a commercial enterprise. "Nasnaran", "Kharna Khatta" and "Jatti Khatti" are long-lived.

General conclusions.—"Kharna Khatta" and "Nasnaran" are best rootstocks for "Malta local" variety.

II (B). Influence of different rootstocks on Malta local Scion (Rootstocks raised by cuttings).

(*a*) **Vigour.**—On the whole rootstocks raised by cuttings produced bigger sized trees of Malta local scion budded on them as compared to those raised by seed. "Jatti Khatti" is associated with most vigorous trees, followed by "Kharna Khatta". "Sweet Lime" is associated with trees of below medium vigour. Both "Mokari" and "Mitha" are most dwarfing stocks in case of Malta local variety.

(*b*) **Cropping.**—"Kharna Khatta" and "Jatti Khatti" are almost grouped and are the most prolific rootstocks. "Sweet lime" is only mediocre as far as its yield-inducing character is concerned. As usual, Mokari has produced the poorest crop in the case of Malta local scion variety.

(*c*) **Quality.**—(*i*) *Size of fruit.*—The discussion already held under the same head in case of rootstocks raised by seed, holds good in this case also.

(*ii*) *Percentage of peel and rag.*—"Mitha" and "Mokari" produced bigger sized fruits and have induced higher percentage of peel and rag in this case also.

(*iii*) *Percentage of T.S.S.*—"Kharna Khatta" induced a higher percentage of total soluble solids followed by "Jatti Khatti" and "Mitha". "Mokari" induced the least percentage of T.S.S.

(*iv*) *Percentage of Juice.*—"Kharna Khatta" increased the juice content considerably. It was followed by "Jatti Khatti" and "Mitha". Here again "Mokari" is the worst stock, as it induced the least percentage of juice in case of scion variety under study.

(*v*) *Percentage acidity.*—Higher sugar content induced by "Kharna Khatta", and "Jatti Khatti" was followed by high acidity in both the stocks. "Mitha" and "Mokari" did not give the proper acidity sugar blend in case of Malta local variety.

(*d*) **Longevity.**—"Mitha" and "Mokari" have a short economic bearing age as these decline quickly. All the other stocks have the same performance as far as longevity is concerned.

General conclusions.—Considering all the factors enumerated above "Kharna Khatta" and "Jatti Khatti" are good stocks for Malta local in case of the set of stocks raised by cuttings.

III (A). Influence of different rootstocks on Malta Blood Red (Rootstocks raised by seed).

(*a*) **Vigour.**—It is interesting to note that "Kharna Khatta" which was most invigorating stocks in the pre-bearing age, declined soon after and was surpassed by "Jatti Khatti". "Jatti Khatti" is associated with most vigorous trees of Malta Blood Red, followed by "KharnaKhatta", "Mitha", "Kharna Khatta", and "Mokari" are the

incompatible stocks for Blood Red and most of the plants in this stock have either died or have declined very badly. "Mitha" and "Mokari" are also very dwarfing stocks. In this respect also "Mokari" is associated with the least vigorous plants of Blood red scion.

(*b*) **Cropping.**—"Jatti Khatti" seems to be the only congenial stock in this set, as the yield on this stock is the maximum and gap in the yield of other stocks is too great. In inducing yield, Jatti Khatti is followed by "Mitha", "Kharna "Kharna Khatta" and "Mokari" in order of merit.

In case of "Jatti Khatti" stock about fifty per cent leaves of the scion variety turn yellow and are shed thereby reflecting that there is some incongeniality of this stock for the scion under study. No doubt this stock is much better than others under study, but probably we have to search for some other stock giving better performance and replacing "Jatti Khatti" in this scion variety.

(*c*) **Quality.**—(*i*) *Size of fruit.*—"Mokari" and "Mitha" both significantly increased the size of fruit in case of Malta Blood Red Scion. The remaining stocks behaved in a similar way. "Jatti Khatti" produced slightly rough skinned fruit in the early stages, but this was corrected in the later years.

(*ii*) *Percentage of juice.*—The juice content was increased considerably by "Jatti Khatti" and "Mokari". These are followed in order of merit by "Mitha" and "Kharna Khatta". Thus "Kharna Khatta" is associated with fruits of Blood Red Malta with lowest juice contents.

(*iii*) *Percentage of peel and rag.*—"Mitha" and "Mokari" which sufficiently increased size of fruit, also produced correspondingly high percentage of peel and rag. "Mokari' induced a higher percentage of peel than "Mitha". "Jatti Khatti" and "Kharna Khatta" behave alike in inducing peel and rag percentage in case of Blood Red scion variety.

(*iv*) *Percentage of T.S.S.*—"Jatti Khatti" induced a higher percentage, followed in order of sequence by "Sweet lime", "Kharna Khatta" and "Mokari".

(*v*) *Percentage of acidity.*—Both "Mokari" and "Sweet Lime" induced highest percentage of acidity and are bracketed in this respect. Thus with proportionately low sugar contents, both these stocks badly deteriorated the quality.

(*d*) **Longevity.**—"Jatti Khatti" is associated with long age of the scion under study. All the remaining stocks are incompatible.

General conclusions.—"Kharna Khatta" which is a very good stock for several scion varieties is incompatible for Blood red variety. Both "Mokari" and "Mitha" are dwarfing stocks. "Jatti Khatti" is the best rootstock for Blood Red.

III (B). Influence of different rootstocks on Malta Blood Red (Stock raised by cuttings)

(*a*) **Vigour.**—The plants budded on stocks raised by cuttings were associated with more vigorous plants than raised from seed. "Kharna Khatta" took a lead in the prebearing age, but then declined gradually and was eventually surpassed by "Jatti Khatti". "Jatti Khatti" is associated with most vigorous plants followed by "Kharna Khatta", "Mitha" and "Jullunduri Khatti" in order of merit. "Kharna Khatta" which was totally incompatible in the set of plants raised from seed, has done much better in the set raised by cuttings. Although it is leading "Jullunduri Khatti" in vigour inducing character, it has been surpassed by later in cropping. Thus for practical purposes, it does not give a congenial combination with Blood red sweet orange.

(*b*) **Cropping.**—The plants of this scion variety budded on "Jatti Khatti" significantly out-yielded all the stocks under trial. This is followed in order of sequence by "Jullunduri Khatti", "Kharna Khatta" and "Sweet Lime". Both Kharna and sweet lime stocks induced poor cropping and are thus worthless stocks for malta blood red.

(*c*) **Quality.**—(*i*) *Size of Fruit.*—"Jatti Khatti" and "Jullunduri Khatti" which produced rough skinned fruit in the initial stages, proved suitable as these appreciably decreased the size of fruit in due course. Both "Kharna Khatta" and "Mitha" produced rough skinned, big sized fruit thereby deteriorating their market value.

(*ii*) *Percentage of juice.*—The juice contents were increased significantly by Jatti

Khatti. Jullundri Khatti and sweet lime followed it in descending order. Kharna Khatta is associated with poorest quality fruit, as the juice contents induced by Kharna Khatta are the lowest.

(*iii*) *Percentage of peel and rag.*—Both Mitha and Kharna Khatta produced bigger sized fruits and percentage of peel and rag was also significantly more than that induced by Jatti Khatti, and "Jullundri Khatti". In the case of Kharna Khatta and Mitha fruit was partly granulated.

(*iv*) *Percentage of total soluble solids.*—"Jatti Khatti" induced maximum total solids in case of Blood red scion variety, followed by "sweet lime," "Kharna Khatta" and "Jullundri Khatti" in descending order.

(*v*) *Percentage of acidity.*—Excepting sweet lime, where acidity was greatly increased. other stocks did not show any difference. Thus "Mitha" stock which induced low T.S.S., produced acidity out of proportion and thus further deteriorated the quality of fruit.

(*d*) **Longevity.**—"Kharna Khatta" and "sweet lime" declined quickly. Only "Jatti Khatti" and "Jullundri Khatti" are compatible stocks and their economic bearing age is good.

IV (A). Influence of different rootstocks on Grape-fruit Marsh seedless (Stocks raised by seed)

(*a*) **Vigour.**—"Jatti Khatti" is associated with most vigorous plants followed closely by "Kharna Khatta", "Chakotra" is a mediocre stock as far as vigour inducing character is concerned. Both "Mokari" and "Mitha", produced the least vigorous plants. "Mokari has induced the least vigour. It is thus established that "Mokari" is worthless stock. "Mitha" also is not at all a suitable stock for all the scions under trial.

(*b*) **Cropping.**—"Kharna Khatta" outyielded all the stocks under trial. It is followed by "Jatti Khatti" and "Chakotra" in a descending order. "Sweet lime" and "Mokari" induce the least cropping and they are not different from each other in this character.

(*c*) **Quality of fruit.**—(*i*) *Size of fruit.*—Both "Mitha" and "Mokari" significantly increased the size of fruit in case of Marsh seedless grape-fruit thereby deteriorating their marketing quality badly. "Mokari" induced a higher percentage of peel than "Mitha". Other stocks, *i.e.*, "Jatti Khatti", "Chakotra" and "Kharna Khatta" produced fruit of proper size.

(*ii*) *Percentage of juice.*—"Jatti Khatti" induced the highest percentage of juice followed by "Kharna Khatta", "Chakotra", "sweet lime" and "Mokari" in order of sequence. As usual "Mokari" and "Mitha" have been found to be the worthless stocks for Marsh seedless grape-fruit.

(*iii*) *Percentage of peel and rag.*—"Mitha" and "Mokari" which significantly increased size of fruit, also increased percentage of peel and rag. Other stocks behaved almost alike.

(*iv*) *Percentage of T.S.S.*—"Chakotra" is leading all others as far as total soluble solids inducing character is concerned. It is followed by "sweet lime", "Kharna Khatta", "Mokari" and "Jatti Khatti" in descending order.

(*v*) *Percentage Acidity.*—Chakotra induced a correspondingly high acidity and thus greatly imporved the quality of Marsh seedless grape-fruit. All other stocks produced similar acidity and there was hardly any difference in each other in their behaviour of inducing acidity.

(*d*) **Longevity.**—"Kharna Khatta", "Jatti Khatti" and "Chakotra" gave a congenial combination with this scion. They are long-lived and have a long economic bearing age.

General conclusions.—"Jatti Khatti", "Kharna Khatta" are the best rootstock for grape-fruit marsh seedless as far as vigour and yield is concerned. "Chakotra" which is mediocre in both vigour and cropping, produces a fine quality fruit.

IV (B). Influence of different rootstocks on Marsh seedless grape-fruit (Stock raised by cuttings)

(*a*) **Vigour.**—The behaviour of stocks is similar to that reported in the other set. It is interesting to note that rootstocks raised by cuttings produced slightly bigger sized plants than those produced on stocks of

apogamic origin.

In this set also "Jatti Khatti" is associated with most vigorous plants followed by "Kharna Khatta", "Mitha", and "Mokari" in order of merit. Both "Mokari" and "Mitha" have been noted conspicuously for their dwarfing character. "Mokari" is the worst stock in this respect.

(*b*) **Cropping.**—"Jatti Khatti" produced most prolific plants followed by "Kharna Khatta". The behaviour of other stocks is similar to that reported in the other set.

(*c*) **Quality of fruit.**—(*i*) *Size of fruit.*

(*ii*) *Percentage of peel and rag.*

(*iii*) *Percentage of juice.*—The behaviour of stocks is the same as already reported under stocks raised by seed.

(*iv*) *Percentage of T. S. S.*—"Sweet lime" induced maximum T. S. S. followed by "Mokari", "Kharna Khatta" and "Jatti Khatti" in descending order.

(*v*) *Percentage of Acidity.*—"Jatti Khatti" which induced least percentage of T.S.S. slightly increased acidity. All the others did not produce significantly different percentage of acidity.

(*d*) **Longevity.**—"Kharna Khatta" and "Jatti Khatti" are long lived. Both "Mokari" and "Mitha" decline quickly and are thus incompatible stocks for grape-fruit Marsh seedless.

General conclusions.—"Jatti Khatti" and "Kharna Khatta" are best rootstocks for Marsh seedless grape fruit. "Mokari" and "Mitha" are quite failure in this scion also.

New trials.—In order to supplement the rootstock work already in progress, new plant material was raised for studying the behaviour of larger No. of stocks (including some new ones in these experiments) on Valencia which was planted late and grape fruit Marsh seedless in the field in September, 1943.

Valencia late scion variety of sweet orange on rootstocks (1) Mitha (2) Atoni (3) Kharna Khatta (4) Jatti Khatti (5) Gadadehi (6) Diwana Khatti (7) Jamberi (8) Seville Kimb (9) sweet lime (10) Jullundri Khatti (11) galgal (12) acid lime or Kaghzi lime.

Grape fruit Marsh seedless on rootstocks.

1. Mithi.	(*C. limon* Linn).
2. Jullundri Khatti.	(*C. limon* Linn).
3. Jamberi.	(*C. limon* Linn).
4. European Lemon.	(*C. limon* linn).
5. Galgal.	(*C. limon* Linn).
6. Sweet lime.	(*C aurantifolia* Swingle).
7. Jatti Khatti.	(*C. limon* Linn).
8. Kharna Khatta.	(*C. karna* Raf).
9. Kaghzi lime or acid lime.	(*C. aurantifolia* Swingle).

The influence of 12 different rootstocks on the vigour of valencia late scion variety of sweet orange.

In the case of Valencia late scion, "Diwana Khatti" is associated with the most vigorous plants. Other stocks can be placed in the following descending order as far as stem girth measurements (serving as index of vigour) are concerned:—

Jamberi.
Jatti Khatti.
Kharna Khatta.
Mithi.
Gadadehi.
Jullundri Khatti.
Seville Kimb.
Atoni.
Sweet lime.
Galgal.
Acid lime or Kaghzi lime.

According to the vigour these rootstocks can be groupd as follows:—

Vigorous.—Diwana Khatti, Jamberi, Jatti Khatti.

Mediocre.—Kharna Khatta, Mithi, Gadadehi, Jullundri Khatti, Seville Kimb.

Least vigorous.—Atoni, sweet lime, galgal and acid lime.

INFLUENCE OF 12 DIFFERENT STOCKS ON CROPPING

Kharna Khatta takes a lead over all others in inducing cropping in valencia late scion variety. Jullundri Khatti, Jamberi, Jatti Khatti and Mithi are also good rootstocks as far as yield inducing capacity is concerned. These can be termed as mediocres. Acid lime also gives good yield and is bracketed with others in this

group, but due to high mortality percentage in this stock, Kaghzi lime means of yield do not seem to be representative and the stock being short lived can be safely excluded from the other promising ones, Diwana Khatti, seville Kimb, sweet lime, Gadadehi, Atoni and Galgal have been noted for inducing poor cropping in case of Valencia late scion variety.

QUALITY

Seville Kimb and Diwana Khatti induced a maximum juice percentage of 50.8. The juice percentage in other stocks ranges from 47.8 to 50.5.

Seville Kimb and Atoni induced total soluble solids as 11.4 and 11.6% respectively. Diwana Khatti and Gadadehi follow them in inducing sugars in valencia late fruits.

The Acid content in case of Atoni is highest followed by Galgal, Seville Kimb, Jamberi, Kharna Khatta, Diwana Khatti, sweet lime, Jullundri Khatti, Mithi and Jatti Khatti in order of sequence.

General conclusions.—Diwana Khatti is a most invigorating rootstock in case of valentia late variety of sweet orange Kharna Khatta induced maximum cropping followed by Jullundri Khatti, Jatti Khatti, Jamberi etc., Seville Kimb produces fruits of better quality Summing up all such factors "Kharna Khatta" has proved to be the best stock for valencia late sweet orange.

Influence of nine different rootstocks on grapefruit Marsh seedless.

(*i*) *Vigour.*—Plants of this scion on European lemon stock are most vigorous followed in order of sequence by those on Jamberi and Mithi, but the difference in girth induced by all the three stocks is not significant. Jatti Khatti, Kharna Khatta and galgal are mediocres as far as vigour inducing capacity is concerned. Plants on "sweet lime" are least vigorous.

(*ii*) *Cropping.*—Jamberi induced maximum cropping in case of marsh seedless variety of grape fruit. Mithi, Jullundri Khatti, and Kharna Khatta follow Jamberi and among themselves these stocks do not show much difference. Galgal, sweet lime and acid lime are poor croppers.

(*iii*) *Quality.*—Jatti Khatti and sweet lime induced better quality as far as juice contents of Marsh seedless are concerned. These are followed in order of sequence by Kaghzi lime, Jamberi, European lemon, Mithi and Jullundri Khatti, Kharna Khatta and Galgal plants are associated with fruit of lowest juice contents.

T. S. S. and acidity.—Jullundri Khatti and acid lime produced better quality fruit as far as T.S.S., acidity blend was concerned.

General conclusions.—Jamberi, Kharna Khatta, Mithi and Jullundri Khatti are better rootstocks for Grape fruit Marsh seedless. Acid lime, Galgal and European lemon plants showed a high mortality thereby reflecting that (*a*) plants of Marsh seedless on these stocks decline quickly and consequently (*b*) the commercial enterpriser gets poor returns during the bearing life of these plants.

RECENT EXPERIMENTS WITH NEW SCION VARIETIES

During the recent years kinnow mandarin, which is a cross between king and willow leaf mandarins, has assumed great importance in this country because of its high juice content, high T.S.S., good quality and richness in flavour. It was therefore felt imperative to evolve, after proper study, a suitable stock scion combination in the case of kinnow scion variety. Jaffa, which is also a high yielding and good quality sweet orange has also been included in recent rootstock investigations. Both these trials are only in the initial stages of experimentation and it is yet too early to arrive at any conclusions, but the present trend of results is given in the following paragraphs.

Influence of seven different rootstocks on the vigour of Kinnow mandarin (*a*) Nursery stage (*b*) in the pre-bearing age.

Plan of the experiment is shown in Fig. 16 and it will be seen that the usual Randomized Block method of layout with six-replications has been adopted in this case.

(*a*) **Vigour in nursery stages**

The following seven rootstocks have been included in this trial:—

(*i*) Jatti Khatti. (*Citrus limon* Linn)
(*ii*) Jullundri Khatti. (*Citrus limon* Linn)
(*iii*) Kharna Khatta. (*Citrus kharna* Ref.)
(*iv*) Mithi. (*Citrus limon* Linn)
(*v*) Seville Kimb. (*Citrus aurantium* Swingle).

LAYOUT PLAN OF KINNOW MANDARIN

Plot No. 4, 5 East

EAST

NORTH | SOUTH

					CENTRAL PATH					
×	×	×	×				×	×	×	×
×	*	*	*	T_3		T_6	*	*	*	×
×	*	*	*	T_6		T_7	*	*	*	×
×	*	*	*	T_2		T_4	*	*	*	×
×	*	*	*	T_5		T_3	*	*	*	×
×	*	*	*	T_1		T_1	*	*	*	×
×	*	*	*	T_7		T_2	*	*	*	×
×	*	*	*	T_4		T_5	*	*	*	×
×	*	*	*	T_4		T_1	*	*	*	×
×	*	*	*	T_2		T_7	*	*	*	×
×	*	*	*	T_6		T_3	*	*	*	×
×	*	*	*	T_5		T_5	*	*	*	×
×	*	*	*	T_3		T_6	*	*	*	×
×	*	*	*	T_1		T_4	*	*	*	×
×	*	*	*	T_7		T_2	*	*	*	×
×	*	*	*	T_2		T_4	*	*	*	×
×	*	*	*	T_6		T_2	*	*	*	×
×	*	*	*	T_3		T_1	*	*	*	×
×	*	*	*	T_1		T_7	*	*	*	×
×	*	*	*	T_4		T_3	*	*	*	×
×	*	*	*	T_6		T_6	*	*	*	×
×	*	*	*	T_7		T_5	*	*	*	×

WEST

REFERENCES :

1. Mithi $=T_1$
2. Kharna Khatta $=T_2$
3. Jatti Khatti $=T_3$
4. Seville Kimb $=T_4$
5. Gadadehi $=T_5$
6. Jullundhri Khatti $=T_6$
7. Jamberi $=T_7$

Experimental=*
Non-Experimental=×

Fig. 16

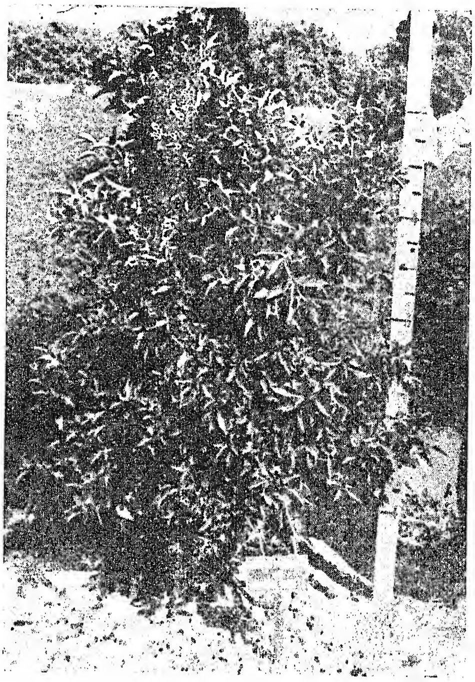


PLATE X.—One year old kinnow mandarin on Kharna Khatta stock.

PLATE XI.—One year old Kinnow mandarin on Seville Kimb stock.

PLATE XII.—One year old Kinnow mandarin on Jullundri Khatti stock.

PLATE XIII.—One year old Kinnow mandarin on Mithi stock.

PLATE XIV.—One year old Kinnow mandarin on Jatti Khatti stock.

PLATE XV.—One year old Kinnow mandarin on Gada Dehi stock.

PLATE XVI.—One year old Kinnow mandarin on Jamberi stock.

PLATE XVII.—One year old Kinnow mandarin on Mithi stock.

PLATE XVIII.—One year old Jaffa sweet orange on Kharna Khatta stock.

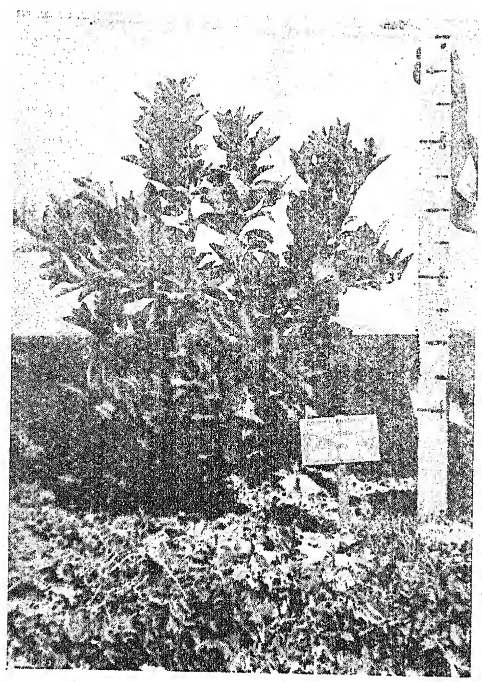


PLATE XIX.—One year old Jaffa sweet orange on Jatti Khatti stock.

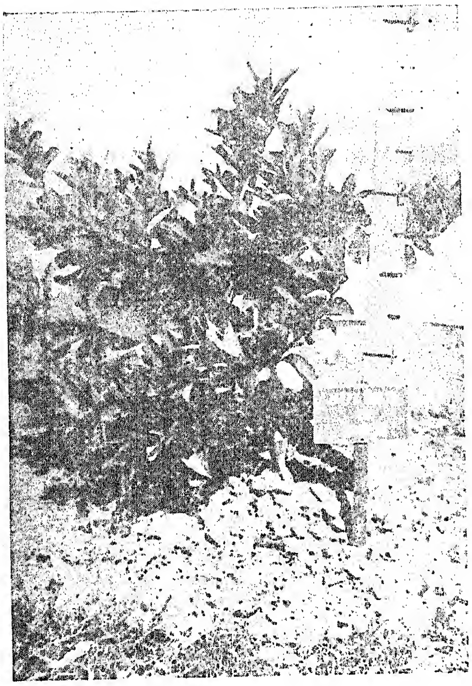


PLATE XX.—One year old Jaffa sweet orange on Jamberi stock.

PLATE XXI.—One year old Jaffa sweet orange on Seville kimb stock.

PLATE XXII.—One year old Jaffa sweet orange on Jullundri Khatti stock.

(*vi*) Jamberi. (*Citrus limon* Linn)
(*vii*) Gadadehi. (*Citrus aurantium*)

From the enclosed table No. 5 it will be seen that Mithi is associated with most vigorous plant of Kinnow mandarin, followed by Seville Kimb, Jatti Khatti, Gadadehi, Kharna Khatta, Jamberi and Jullundri Khatti in descending order. Jatti Khatti has produced least vigorous plants of this scion variety in the nursery stages.

(*ii*) *Height.*—It is clearly indicated by the figures of height given in the enclosed table No. 6 that Mithi leads all the other stocks in inducing height in the nursery stages. It is followed by Seville kimb. Seville kimb, Jamberi and Kharna Khatta are associated with plants of medium hieght and among themselves they are not significantly different, as far as their character of inducing height in the scion variety is concerned.

General conclusions.—Mithi rootstock has shown a tendency to produce bigger sized plants in the nursery stage, which is a very desirable character from the nurseryman's view-point, as he can produce good sized saleable plants in a shorter period and can get a premium over other plants of same age, for the attractive size of plants on Mithi rootstock.

(*b*) **Vigour in the pre-bearing age.**—The enclosed Table No. 7 shows stem girth induced by various stocks, stem girth is an index of tree vigour as agreed to by various workers in the world.

As will be seen from the Table No. 7 Mithi and Kharna-Khatta were the most vigorous rootstocks in the initial stage, but Kharna Khatta has now surpassed all the stocks under trial. Mithi comes next and other stocks can be placed in the following descending order:—

1. Jatti Khati. } Bracketed.
2. Seville Kimb. }
3. Jamberi.
4. Jullundri Khatti.
5. Gadadehi.

Height.—From the means of height figures induced by various rootstocks given in the Table No. 8, it will be seen that Mithi which led all the stocks in the initial stage, has been gradually surpassed by Kharna Khatta. Kharna Khatta has induced maximum height in kinnow scion, followed by Mithi, Jatti Khatti, Gadadehi and Jullundri Khatti are almost bracketed in inducing height and are thus mediocre stocks for kinnow, Seville Kimb and Jamberi are associated with least vigorous plants of kinnow.

General conclusions.—Kharna Khatta, which appear to be universal stock for almost all scion varieties leads in this case. Kharna Khatta is totally incompatible for Blood Red Malta, but in all other cases it is either best or one of the best stocks. Its nursery performance is also good and it becomes fit for budding much earlier than many other stocks.

Influence of six different rootstocks on the vigour of Jaffa, Sweet Orange, (*a*) nursery stage, (*b*) in the pre-bearing age.

The following rootstocks have been included in this trial:—

1. Jatti Khatti. (*Citrus limon* Linn).
2. Jullundri Khatti. (*Citrus limon* Linn).
3. Mithi. (*Citrus limon* Linn).
4. Jamberi. (*Citrus limon* Linn).
5. Kharna Khatta. (*Citrus kharna* Raf).
6. Seville Kimb. (*Citrus aurantium*).

Layout plan of this experiment is quite similar to that of the kinnow experiment. The enclosed plan shows that three plants are kept as unit of plot and there are six replications. The usual Randomized Block method of layout has been followed. Non-experimental rows have been kept on both the water channel sides as well as on the Road side. (Fig. 17).

The influence of various stocks in the nursery stage as well as in the pre-bearing age is discussed separately in the following paragraphs.

(*a*) **Vigour in Nursery Stage.**

(*i*) In the initial stage mithi was leading in stem girth, but later on Jatti Khatti induced more vigour and gradually took a lead over all the others. Thus Jatti Khatti is associated with most vigorous plants of Jaffa in the nursery stage. The enclosed Table No. 9 shows the behaviour of various stocks on Jaffa scion variety. In vigour Jatti Khatti is followed by Mithi, Kharna-Khatta is a mediocre stock and

LAYOUT PLAN OF JAFFA (SWEET ORANGE)

Plot No, 4, 5 West

EAST

NORTH | SOUTH

					CENTRAL PATH					
×	×	×	×				×	×	×	×
×	*	*	*	T_6		T_6	*	*	*	×
×	*	*	*	T_4		T_1	*	*	*	×
×	*	*	*	T_3		T_4	*	*	*	×
×	*	*	*	T_5		T_2	*	*	*	×
×	*	*	*	T_2		T_3	*	*	*	×
×	*	*	*	T_1		T_5	*	*	*	×
×	*	*	*	T_1		T_1	*	*	*	×
×	*	*	*	T_5		T_4	*	*	*	×
×	*	*	*	T_4		T_2	*	*	*	×
×	*	*	*	T_3		T_3	*	*	*	×
×	*	*	*	T_2		T_6	*	*	*	×
×	*	*	*	T_6		T_5	*	*	*	×
×	*	*	*	T_3		T_6	*	*	*	×
×	*	*	*	T_1		T_5	*	*	*	×
×	*	*	*	T_4		T_2	*	*	*	×
×	*	*	*	T_6		T_3	*	*	*	×
×	*	*	*	T_5		T_1	*	*	*	×
×	*	*	*	T_2		T_4	*	*	*	×
×	×	×	×				×	×	×	×
×	×	×	×				×	×	×	×

WEST

REFERENCES :

1. Mithi $=T_1$
2. Kharna Khatta $=T_2$
3. Jatti Khatti $=T_3$
4. Seville Kimb $=T_4$
5. Jullundri Khatti $=T_5$
6. Jamberi $=T_6$

Experimental = *
Non-Experimental = ×

Fig. 17

TABLE 5

Showing mean stem girth in (mms) of Kinnow Mandarin (in Nursery stages) as influenced by various rootstocks. Means of girth in different months.

Serial No.	Treatments		September 1959	October	November	December	January 1960	February
1	Jatti Khatti	...	8.05	8.84	9.7	10.15	10.21	10.24
2	Jullundri Khatti	...	7.17	7.94	8.71	8.99	9.10	9.26
3	Karna Khatta	...	8.08	8.43	9.27	9.64	9.74	9.96
4	Mithi	...	8.31	9.17	10.02	10.52	10.65	11.13
5	Seville Kimb	...	8.47	9.2	9.85	10.23	10.32	10.72
6	Jamberi	...	6.95	7.8	8.4	9.24	9.28	9.62
7	Gadadehi	...	7.90	8.71	9.36	10.03	10.11	10.2

TABLE 6

Showing mean height in (cms) of Kinnow Mandarin (in Nursery stages) as influenced by various rootstocks, Means of height in different months.

Serial No.	Treatments		September 1959	October	November	December	January 1961	February
1	Jatti Khatti	...	60.63	66.3	67.55	67.87	68.3	67.85
2	Jullundri Khatti	...	59.21	63.13	66.91	67.55	67.11	67.73
3	Kharna Khatta	...	65.46	72.36	76.28	77.27	77.63	79.36
4	Mithi	...	73.34	82.55	86.44	87.15	87.06	88.85
5	Seville Kimb	...	69.56	76.6	79.74	81.06	81.12	76.82
6	Jamberi	...	67.50	72.38	77.67	78.30	78.38	77.84
7	Gadadehi	...	62.1	70.91	72.42	72.39	72.44	76.41

TABLE 7

Showing mean girth of Kinnow Mandarin as influenced by various rootstocks.
Means of girth in (mms) during different months.

Serial No.	Treatments	July, 1960	August	Sept.	Oct.	Nov.	Dec.	Jan. 1961	Feb.	Mar.	April	May
1	Mithi ...	13.54	15.39	18.30	22.03	23.75	24.66	24.7	24.82	25.3	27.7	30.2
2	Kharna Khatta ...	13.54	15.7	20.18	24.53	26.38	27.05	27.46	27.72	28.3	30.8	33.7
3	Jatti Khatti ...	10.82	12.25	14.42	17.39	19.0	19.81	19.96	20.17	20.6	23.5	25.6
4	Seville Kimb ...	12.51	13.23	15.04	17.94	19.58	20.18	20.51	20.72	21.2	23.5	25.3
5	Gadadehi ...	11.16	12.46	14.74	17.30	18.7	19.5	19.7	19.91	20.3	22.7	25.4
6	Jullundri Khatti ...	10.38	12.03	14.34	17.67	19.18	20.0	20.21	20.35	20.6	22.8	25.6
7	Jamberi ...	11.73	12.75	14.97	18.25	19.8	20.5	20.59	20.7	21.7	23.1	25.9

TABLE 8

Showing mean height of Kinnow Mandarin as influenced by various rootstocks.
Means of height in inches during different months.

Serial No.	Treatments	July, 1960	August	Sept.	Oct.	Nov.	Dec.	Jan. 1961	Feb.	March	April	May
1	Mithi ...	32.26	33.99	35.94	40.78	42.78	43.08	43.4	42.52	42.6	44.5	46.5
2	Kharna Khatta ...	30.09	34.17	39.47	46.27	48.65	48.93	49.34	48.33	48.5	53.5	54.1
3	Jatti Khatti ...	23.56	27.21	28.06	35.11	37.55	37.86	38.07	36.99	37.3	40.3	41.2
4	Seville Kimb ...	30.28	30.93	32.28	35.9	36.81	36.83	36.96	35.15	35.4	38.0	38.8
5	Gadadehi ...	27.36	28.52	30.63	34.25	35.3	37.18	35.61	34.96	35.3	38.1	40.1
6	Jallundri Khatti ...	21.16	23.05	27.88	35.54	37.3	37.18	37.23	36.20	36.4	40.1	40.1
7	Jamberi ...	25.21	27.84	30.65	35.74	35.51	36.58	35.72	34.04	36.4	37.8	38.9

TABLE 9

Showing mean stem girth in (mms) of Jaffa (Sweet orange) in Nursery stages as influenced by various rootstocks. Means of girth in different months.

Serial No.	Treatments		Sept. 1959	October	November	December	Jan. 1960	February
1	Jatti Khatti	...	10.87	12.22	13.17	13.4	13.54	13.54
2	Jullundri Khatti	...	8.41	8.86	9.66	9.78	9.91	9.92
3	Kharna Khatta	...	9.68	10.5	11.46	11.78	11.85	11.95
4	Mithi	...	10.96	11.99	12.83	13.44	13.54	13.54
5	Seville Kimb	...	8.43	9.13	9.87	10.43	10.58	10.03
6	Jamberi	...	8.16	8.85	9.65	10.11	10.22	10.57

TABLE 10

Showing mean height in (cms) of Jaffa (Sweet orange) in Nursery stages as influenced by various rootstacks. Means of height in different months.

Serial No.	Treatments		Sept. 1959	October	November	December	Jan. 1960	February
1	Jatti Khatti	...	64.56	68.44	70.54	71.02	70.65	72.42
2	Jullundri Khatti	...	53.33	55.77	57.56	59.02	59.09	59.66
3	Kharna Khatta	...	71.55	77.58	79.63	81.65	82.03	85.04
4	Mithi	...	76.61	86.62	90.15	91.9	91.03	93.04
5	Seville Kimb	...	57.95	61.87	64.58	66.10	65.99	68.12
6	Jamberi	...	64.7	68.41	71.35	71.70	71.57	73.10

induces greater vigour than Jullundri Khatti, Seville Kimb and Jamberi.

(*ii*) **Height.**—From the enclosed Table No. 10 showing height in different months it will be seen that Mithi continues to lead all the others under trial. It will be of still greater interest that Jatti Khatti, which induces maximum stem vigour does not produce plants of comparative height. Mithi stock is thus associated with highest Jaffa Plants in the nursery followed by Kharna Khatta, Jamberi, Jatti Khatti and Seville Kimb in order of sequence.

General conclusions.—Mithi, Kharna Khatta and Jatti-Khatti appear to be promising stocks.

(*b*) **In pre-bearing age.**

(*i*) The enclosed Table No. 11 clearly shows that Mithi, which took a lead in inducing maximum vigour in the initial stages, maintained its position throughout. It is followed by Jatti Khatti, Kharna Khatta, Seville kimb and Jamberi which may be called mediocre stocks as far as vigour inducing character in the pre-bearing age is concerned. Jullundri Khatti does not seem to give a congenial combination with Jaffa scion variety.

(*ii*) *Height.*—In this case also Mithi leads all the stocks. It is followed in order of sequence by Jatti Khatti, Kharna Khatta, Jamberi, Seville kimb and Jullundri Khatti. In this case also Jullundri Khatti is associated with weak plants of Jaffa scion variety. (Table No. 12).

General conclusions.—Mithi, Jatti Khatti and Kharna Khatta show promise in the case of Jaffa sweet orange. This is only the trend of results in the initial stages of orchard life, definite conclusions of practical importance will be drawn after several years, when almost entire bearing age of trees will be studied.

TABLE No. 11

SHOWING MEAN GIRTH OF JAFFA (SWEET ORANGE) AS INFLUENCE BY VARIOUS ROOTSTOCKS.

Means of girth in (mms) during different months.

S. No.	Treatments.	July, 1960.	August.	Sept.	Oct.	Nov.	Dec.	Jan., 1961.	Feb.	March.	April.	May.
1.	Mithi ...	15.35	17.30	20.18	23.4	24.83	25.4	25.91	25.91	26.1	28.8	31.0
2.	Kharna Khatta ...	13.50	15.13	18.16	20.98	22.63	23.6	23.77	23.83	24.0	25.1	27.8
3.	Jatti Khatti ...	14.44	16.51	19.43	22.12	23.39	23.85	24.36	24.56	24.77	27.3	29.1
4.	Seville Kimb ...	12.54	14.50	17.07	19.96	21.31	22.1	22.28	22.39	22.6	24.7	26.1
5.	Jullundri Khatti ...	9.72	14.37	12.85	14.59	15.91	16.5	16.65	16.73	16.9	18.9	19.9
6.	Jamberi ...	11.22	13.52	15.35	18.98	20.4	21.0	21.15	21.25	21.5	24.0	25.5

TABLE No. 12

SHOWING MEAN HEIGHT OF JAFFA (SWEET ORANGE) AS INFLUENCE BY VARIOUS ROOTSTOCKS.

Means of height in inches during different months.

S. No.	Treatments.	July, 1960.	August.	Sept.	Oct.	Nov.	Dec.	Jan., 1961.	Feb.	March.	April.	May.
1.	Mithi ...	32.11	34.5	36.39	38.83	40.51	39.7	40.62	39.44	40.0	42.7	42-.8
2.	Kharna Khatta ...	27.07	29.11	32.24	37.27	38.65	38.7	39.20	37.67	38.8	40.3	43.3
3.	Jatti Khatti ...	24.08	27.97	31.77	39.17	38.98	39.1	39.20	38.05	38.5	40.9	46.0
4.	Seville Kimb ...	24.5	25.89	29.35	33.29	23.3	34.3	34.37	33.26	33.7	35.4	39.1
5.	Jullundri Khatti ...	17.06	19.13	2171.	26.34	27.36	27.5	27.53	26.62	27.0	28.8	31.1
6.	Jamberi	22.46	25.85	27.48	31.96	33.15	33.5	33.38	32.51	33.2	35.2	39.8

GLOSSARY

Sr. No.	Local Names	Possible English Equivalents	Scientific Names
1.	Atoni	Elephant Sangtra	*Citrus ruguloso* Tan.
2.	Chakotra	Shaddock	*Citrus grandis* Linn.
3.	Mokari	Citron	*Citrus medica* Linn.
4.	Citranges	...	*Ponci: us trifoliata* × *Citrus sinensis.*
5.	Citrangequat	...	*Ponicirus trifoliate* × *Citrus sinensis* × *Fortunella Sps.*
6.	Grapefruit	Grapefruit	*Citrus paradise* Macfadye.
7.	Kharna Khatta	...	*Citrus karna* Raf.
8.	Kumquate	Kumquat (oval)	*Fortunella margarita.*
9.	Khatti	Rough Lemon	*Citvus limon* Linn.
10.	Jullundri Khatti	Smooth-Skinned Lemon	*Citrus limon* Linn Burm.
11.	Mitha	Sweet Lime	*Citrus aurantifolia* Swingle.
12.	Kaghzi Nimboo	Kaghzi Lime or Acid Lime	*Citrus aurantifolia* Swingle.
13.	Lemon	Elephant Lemon or Hill lemon	*Citrus limon* Linn.
14.	Limquats	...	*Citrus aurantifolia* × *Fortunella Sps.*
15.	Sangtra	Mandarin	*Citrus reticulata.*
16.	Tangerin	Tangerin	*Citrus reticulata.*
17.	Mithi	Sweet Lemon	*Citrus limon* Linn.
18.	Nasnaran	...	*Citrus aurantifolia* Swingle.
19.	Jamberi	...	*Citrus limon* Linn.
20.	Khatta	Sour Orange	*Citrus aurantium* Linn.
21.	Kimb	Sour florida or Seville sour or bitter orange	*Citrus aurantium* Linn.
22.	Gadadehi	...	*Citrus aurantium* Linn.
23.	Diwana Khatti	...	*Citrus* Species.
24.	Tangelo	Tangelo	*Citrus reticulata* × *Citrus paradise.*
25.	Tangora	...	*C. sinensis* × *C. reticulata.*
26.	Malta	Sweet Orange	*C. sinensis* Osbeck.
27.	Galgal	...	*C. limon* Osbeck.
28.	Narangi	Tangerin	*C. reticulata.*
29.	Sylhet Lime	Sylhet Mandarin or Marmlade Orange	*C. reticulata.*
30.	Trifoliate	Trifoliate	*Poncirus trifoliata*

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CONTROL OF WEEDS IN ORCHARDS

BY

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Weeds are a great menace for the ordinary crops and rob the soil of the precious nutrients which might have been utilized by the useful plants. In the orchards they are equally harmful and sometimes they harbour insects and fungal diseases and likely to spread them to the trees. The problem of weed control, therefore, in orchards is very important indeed.

There are two types of weeds, namely Kharif and Rabi.

Kharif Weeds

They appear during Summer and comprise of "Baru" (*Sorghum halepense*), Motha (*Cyperus rotundus*), Khabbal (*Cynodon dactylon*) and Dab (*Desmostachya bipinnata*).

Rabi Weeds

These appear during Winter and comprise of "Pohli" (*Carthamus oxyacantha*) "Piazi" (*Asphodelus tenuifolius*), "Bathu" (*Chenopodium album*), "Itsit" (*Boerhaavia repens*), "Shahtara" (*Fumaria parviflora*) "Lehli" (*Convolvulus arvensis*) etc.

Out of these the Kharif weeds like "Baru" and "Motha" are very troublesome for orchards and control measures are necessary for their eradication.

Control Measures

Cultural Methods. The control of weeds is largely a matter of good farm management and certain practices, if carefully followed, will reduce weed problem to a minimum. A judicious programme of cultivation should be followed. It is recommended that the orchard should be ploughed up thoroughly throughout summer and no crops are grown. During winter season leguminous crops should be grown to curb down weeds. The best crop to be grown is berseem which will not only bring handsome income to the growers but also have a healthy effect on the growth of trees. Since weeds often spread through animal manure only well rotten manure should be used which has been allowed to rot for four to six months.

Chemical Methods

Control for 'Baru'. This weed is a great menace and is propagated both by the small stem pieces just near the ground known as rhizomes as well as by seeds. In Barani areas like Rawalpindi, Jhelum, Campbellpur it assumes great importance and robs the orchard of their food nutrients and is a great hinderance in cultivation. Detailed experiments have been conducted by the Department of Agriculture to find out control measures for this weed. Atlacide (Trichloro acetate) was tried first, though it was successful in controlling this weed but the cost was prohibitive. Besides it had a bad effect on soil. Dowpon (2, 2-dichloropropionic acid) was later on tried and was found effective in destroying "Baru" up to 98% in small plots and in the orchard. Six to ten per cent resprouting of the plants was observed the following year which can be eliminated by ploughing.

It may not be out of place to mention that in foreign countries a combination of chemical and cultural treatment is also recommended. The spraying should be done twice during the months of June and September according to the following recipe:—

Dowpon (2, 2-D) ... 10 lbs. per acre.

Water ... 150 gallons per acre.

Basfapon whose active ingredient is also 2, 2-D has been tried last year and found to be even more effective and probably the cost will be reduced to half.

Control of "Motha". This is a very hardy weed because it has got small nuts below ground for perennation. This can be easily killed by spraying accordingly to the following formula:—

Fernoxone (2, 4-D) ...	2 lbs. per acre.
Water	...150 gallons per ace.

Spraying should be done twice during the months of June and September. It will appear strange as ordinarily this weedicide is meant to kill the dicot weeds in monocot crops yet it is effective in the exterminati n of "Motha".

Control of Rabi Weeds. As a commendable practice orchard should be intercro ped with berseem during winter. Weeds will, therefore, are not going to present a big problem. In cases where cultivation has not been done thoroughly, weeds might also occur in the orchard. These can be easily controlled by spraying Tropotox (4-Chloro-2-Methylphenoxybutyric acid). Experiments conducted show that all the weeds can be effectively eradicated when berseem is 6'' high (3 leaf stage) according to the following formula:—

Tropotox (MCPB) ...	2 pts. per acre
Water	... 150 gallons per acre.

If the land has not been intercrop ed then weeds like "Piazi" and Pohli are likely to appear. They can be killed easily by using Fernoxone (2, 4-D) at the rate of on pound per acre diluted in 150 gallons of water.

SOME GROWTH FACTORS AND THEIR RELATION TO FLOWERING IN PLANTS

BY

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Introduction

In order to obtain regular and remunerative yields, the grower must be fully conversant with the growth morphology of his trees which is nothing but the outer manifestation of the physiological conditions of the plants. In a more generalized form it is admitted that the time of growth initiation, its morphological origin and seasonal elongation have a direct bearing on fruit bud differentiation in fruit trees. Physiologists and horticulturists realizing the importance of this have dealt with the different aspects of this fundamental problem to elucidate the relationship between certain growth features and fruiting.

Bonner (1952) remarked that all plants must pass through a vegetative stage of growth in order to attain the stage of ripeness to flower. Once the ripeness to flower conditions has been attained, some plants flower without further environmental stimulation.

Meyer (1952) gave the description of transformation from vegetative state to flowering state, according to him, some vegetative apical meristems, continue to grow as such indefinitely but sooner or later, in the life history of most plants, some of them become transformed into reproductive meristems. The vegetative stage may be considered a basic one less differentiated physiologically and morphologically than reproductive state. A shift from the vegetative into reproductive state, may occur, however, whenever environmental conditions become such that the requisite internal conditions leading to flower induction are established within the meristem.

The first steps in the formation of a vegetative to a reproductive meristem are invisible physiological changes resulting in metabolic conditions within the meristematic cells which completely alter the differentiation pattern of the meristem. The most pronounced phyiological and developmental changes in the plants existance occur in the brief period of differentiation. The whole pattern of structural differentiation changes profoundly during the transformation of a vegetative to a reproductive meristem, reflecting equally deep-seated changes in metabolism.

Loomis (1932) remarked "Within our definition of differentiation sexual reproduction in seed plants consists of alternating cycles of differentiation and growth. The flower bud is initiated by differentiation, it grows into flower. The gametes are differentiated, the fruit and fertilized fruit grow. With this rapid swing from one type of development to the other it is commonly impracticable to alternate the G/D Balance and we compromise by growing fruiting plants under intermediate conditions so that differentiation and growth can occur simultaneously.

A study of the correlation between vegetative development and fruiting into tomato plants by Murneek (1932) revealed that when tomato plants were diflorated or the fruits were removed as rapidly as they set the plants continued to grow vegetatively. If however the fruits were allowed to remain on the plant and enlarge, vegetative development and the flower formation gradually slowed down as more and more fruit began to develop.

The retarding effect of the enlargement of fruits upon continued vegetative growth and flower development, according to Murneek (1932), resulted from the virtually complete monopolization of all the nitrogenous compounds in the plants by the fruits. Whereas carbohydrates were found to be

stored in considerable quantities in both the fruit and vegetative organs. In general the more nitrogenous compounds available the more fruits are set and started to develop before inhibition of flowering and vegetative growth begins.

Walster (1920) stated that environmental factors may check growth and lead to carbohydrate accumulation and that fruitfulness may result provided vegetative development is not seriously retarded or altogether stopped.

Eaton and Johan (1944) and Eaton and Rigler (1945), studied the interrelationship between vegetative and reproductive growth. The reduction in vegetative growth which was found to accompany the formation of bolls was attributed to the small quantity of carbohydrates reaching to root system. Most of the carbohydrates manufactured by the leaves found their way to the developing fruits instead of going to root system. The effect of relatively low supply of carbohydrates to root system was to reduce markedly the absorption of mineral salts which in turn restricted vegetative growth.

Meyer (1952) concluded that the growth and flowering or fruiting correlations are due to some modifications in the internal food relations of the plants. These modifications are of such a large proportion of available food to developing flowers or fruits that other organs suffer a deficiency and hence are checked in growth.

Borthwick and his associate in 1938, concluded that the correlations between vegetative and flower growth, once the ready to flower condition is established appear to be most satisfactory, explainable on the basis of auxin controlled food competition. Vegetative buds may monopolize food supplies and prevent the growth of flowers or especially of young fruits.

From the perusal of above it appears that vegetative growth and flower formation have a definite correlation. There are various factors which influence flower bud differentiation but in this paper, factors mostly related to vegetative growth and their effect on flower bud formation will be discussed.

II. Review of Literature

The scientists have maintained that there exists a definite relationship between the growth of a tree and its fruitfulness. A knowledge of this relationship enables a grower to regulate his cultural operations effectively to attain maximum profits. Such correlations have been extensively studied in case of horticultural plants. According to Kraus and Kraybill (1918) given a knowledge of the relationship between certain radially distinguishable growth characters and productivity in fruit trees. The aim of the cultural operations may then be made more direct and effective towards attaining the desired end.

Swarbrick (1928) working with apple has clearly shown that the cessation of growth is directly correlated with the time of fruit or flower bud formation.

Hooker (1925) emphasized the importance of the relationship of growth features to fruit bearing potentialities in fruit trees.

Gourley (1915), Heinike (1917), Edminister (1917), Dorsey and Knowlton (1925) and Roberts (1942) working in various fruit trees deciduous in nature, Lal Singh and A. A. Khan (1940), Musahib-ud-Din (1943) working on mangoes. Jaggit Singh (1944) working on Mandarin orange, have proved a correlation between certain growth features and bearing in various fruit trees with which they worked. They found close relationship between flower bud formation and vegetative growth characters.

The importance of the leaf area in influencing flowering and fruitfulness can very well be gauged by the findings of Goff (1900). Bradford (1905), Magness (1917), Gourley (1917), Roberts (1920), Chandler (1925), Swarbrick (1928) who hold that the leaf area commensurates with fruiting, and flowering.

Swarbrick (1932), Vyvan and Evans (1932) are of the opinion that mean leaf area per unit length of shoot effects flowering. Hamilton (1932) and Devries (1932) hold that a vigorous leaf system is a key to flower bud formation but on the other hand Gourley (1915) and Swarbrick (1928) found that over leafiness checks blossom bud differentiative.

Roberts (1926) working with apple, concluded that the trees with intermediate growth and medium sized shoots were

more fruitful perhaps due to having favourable carbohydrate nitrogen ratio.

Patridge (1919) working on apple demonstrated that flower bud formation and in turn, yield was greatly increased with increased amount of growth.

Gourley (1917) who worked on the problem of alternate bearing in case of apples asserted that more leaf area was produced in the "on year" than in "off year".

Musahib-ud-Din (1943) working with mangoes stated that the leaf area was more in terminal rosette of flowering shoots as compared with the non-flowering ones.

Read (1928) who working on the growth of lemon shoots concluded that there are many factors which influence growth but there seems good reasons to believe, that shoots on the apical parts of the branch attain and hold their dominance by drawing upon the supplies of growth producing materials in the parent branch as well as by inhibiting the growth promoting substance in the lateral buds situated below them. It has generally been observed that buds in upper positions are early to grow, consequently utilizing the soluble substance from the sub-apical regions and depriving the lower ones by that amount. It would naturally help the terminal shoots to grow more as compared with lateral ones.

Kraus and Kraybill (1918) working with tomato, found the shoots of medium vigour more prone to flower formation because of favourable carbohydrate nitrogen ratio. Leaf area has also been found to be more in case of fruitful and more flowerin shcots, a definite tendency exists for the blossoming shoots to have more leaf area' as perhaps due to the fact that the foliar-canopy is responsible for the elab ration of synthetic food products. The shoots with greater leaf area bore greater number of blossoms.

Brown and M. A. Khan (1939) working on raspberry found that in a given variety other factors being constant, the amount of foliage will directly determine the number of flowers borne and productivity.

Hooker (1925) concluded that the significance of carbohydrates accumulation which has been found invariably to accompany fruit bud differentiation in apple spurs seems to be in the inhibition of leaf bud formation. At the time of bud differentiation, a bud must become either a leaf or a fruit bud. If growth is a consecutive reversible reaction, it might be expected that the accumulation of carbohydrates in the vicinity of the bud at the time of differentiation would affect the morphological development of the growing point in such a way as to suppress the development of photosynthetic machinery and so favour the formation of floral parts.

Swarbrick, T. and Naik, K. C. (1932) working on apples concluded that leaf area was found to be closely related to the production of carbohydrates and synthetic plant products generally, and in this way leaf area is undoubtedly directly related to the amount of reserve carbohydrates stored in wood stems. Variations in leaf area was found to have profound effect on flower bu formation.

Robert (1920), Magness (1927), Gourley (1917) and Swarbrick (1932) have clearly demonstrated that a direct relation exists between leaf area and flower bud formation. Since leaves constitute such a large part of the fruit spur system and the current years yield any factor which affects leaf area may also be expected to affect fruit production.

The importance of local or adjacent leaf area upon flower bud production is stressed by many workers. Picket (1917) in his studies on strawberry plants, showed a strict correlation between total production of fruit and total amount of foliage per plant.

Potter (1941) have studied deflorated spare which in a sense are non bearing. If all the spurs on a heavily blooming tree over deflorated considerable growth took place in the secondary shoots, fruit buds were formed and starch accumulated somewhat. If only half the spurs were deflorated and the remainder allowed to bloom and set fruit growth a fruit bud formation were depressed and less starch accumulated.

Harvey (1921) found that defoliation of spurs seriously restricted the differentiation of flower buds, perhaps due to the fact that carbohydrates were made the limiting factor to flower bud formation. Decreasing carbohydrates without disturbing the nitrogen supply would be assumed to have altered

relations in favour of nitrogen to a point where the resulting conditions no longer allowed flower bud formation to take place.

Chandler (1951) postulated that leaves supply a harmone that can induce flowering when cell division begins in the bud, but that ausin moving down from a terminal inflores nce bud presents cell division in lateral buds, when the terminal bud is removed cell division can begin and the leaf harmone can act on these dividing cells to cause formation of an inflorescence instead of a shoot.

Finch (1935) working with the physiology of apple varieties, presented data to give evidence that the relative position between the extremes of vegetativeness that tree of a variety normally occupy is correlated with the typical fruiting performance of trees of the variety. The degree of vegetativeness is closely related to or determined by the chemical composition of the tree, particularly as regards carbohydrate nitrogen cont nts.

The starch and total carbohydrate contents and starch nitrogen and total carbohydrate nitrogen ratios were highest in flowering terminal shoots of trees of biennially bearing varieties. They were next highest in terminal shoots of trees of regularly but shyly bearing varieties. They were lowest in the non-flowering, non-fruiting terminal shoots of trees of biennially bearing varieties. Flowering was found to be correlated with character of terminal growth. The time and rate at which terminal growth with its accompanying leaf formation appeared to be highly correlated with the fruitfulness of the resulting growth.

Baily (1928) and Homlett (1926) attempted to increase flowering of apples in the off year by thinning during the fruiting year. Only complete removal of all flowers on a particular spur in the bud stage was effective. Growth and set of young fruits of apple are critically affected by the supply of growth materials especially water and nitrogenous compounds.

Edminister, A. F. (1917) showed a high degree of correlation between the length of shoots and the percentage of lateral buds breaking and of those forming fruit spurs, the longer shoots being the more productive of both side shoots and spurs. A certain correlation also existed between the diameter of shoots and the percentage of their lateral buds breaking and of those forming fruit spurs, the stouter shoots being the more productive of both side shoots and spurs.

Robert (1926) working with healthy variety of apple suggested a direct relation between growth and flowering character. Strongly vegetative tree making a long, slender growth with a high nitrogen nutrient and also weakly vegetative trees making a short slender growth with a low nitrogen nutrient were non-fruitful. Between these two extremes of vegetative condition were trees having a relatively thick and moderately long growth which was fruitful. Chemical analysis of these different types of growth revealed that the non-flowering strongly vegetative trees were high in nitrogen and low in carbohydrates especially starch, that the weakly vegetative unfruitful trees were low in nitrogen and in carbohydrates and that the flowering trees were of intermediate composition.

Drinkard (1910) remarked that, flower growth of apples which starts in June of the year before fruit, fails in competition with fruit on the same spur.

Luckwell (1953) suggested further work to determine whether auxin production by the young fruit prevents floral induction or whether food competition by the fruit prevents the floral growth.

III. Conclusions

From the work referred in this paper, it is quite clear that a strong correlation exists between different growth features and flowering potentialities.

As reported by majority of workers, the most conducive conditions for change over from vegetative stage to flowering stage is when the trees are in medium conditions of vegetative growth. Highly vegetative trees with increasingly large leaf area, extension growth and other such growth characters remain barren. The most weak and having sparce foliage, very small shoots, with less diameters, are also those which for all practical purposes remain barren. The reasons that the flowering shoots have relatively more leaf area, and extension growth suggest a favourable nitrogen/carbohydrate balance in such

trees which is attributed to flow ring in such trees.

Kraus and Kraybill (1918) working on correlation studies between vegetative growth and flowering gave a satisfactory explanation of different behaviour of trees, showing different vegetative characters. They grouped the plants into four categories. The characteristics of plants in these four groups were outlined by them as follows:

Class I. The plants included in this group are those which are decidedly carbohydrate deficient. This low rate of carbohydrate manufacture, may be due to shading, defoliation, or other factors which greatly reduce the rate of photosynthesis. Such plants have light green foliage and soft, spindly stems. The length growth may be considerable but diameter increase is small, such plants are called weakly vegetative. In tomatoes, it was found that such plants failed to full bloom.

Class II. The plants in this group are rank growing and vigorously vegetative with large, thick stems and leaves. The colour of the foliage is dark green. In tomatoes it was found that flowers in this class of plants reached full bloom but did not set fruit. It is evident that such plants suffered from slight carbohydrate deficiency. This deficiency results not from failure of carbohydrate synthesis but rather as a result of rapid utilization of carbohydrates in the formation of organic nitrogenous compounds (in the presence of an abundant supply of inorganic nitrogen).

Class III. The plants included in this class are those which flower and fruit abundantly as a result of sufficient carbohydrate and nitrogenous substances. Carbohydrates are not limiting as in first two classes.

Class IV. The plants in class IV make little vegetative growth and are also known as weakly vegetative as are the plants in class I. The foliage tends to be of a yellowing cast and the growth of all vegetative parts is restricted.

As opposed to class I, nitrogen is the limiting factor. Furthermore as a result of restriction in the synthesis of organic nitrogenous compounds from inorganic nitrogen and carbohydrates, the reserve carbohydrate content is high being more or less proportional to the degree of the deficiency of nitrogen. These classes are primarily of value in presenting in a rather specific manner the relationship between the composition of the plant as regards nitrogen and carbohydrates and its response in flowering and fruiting.

Gardner (1939) pointed out that carbohydrate accumulation seems associated with flower bud differentiation and the conditions for carbohydrate accumulation vary with the growing habit and bearing habit of the plant.

Chandler (1951) remarked that the tendency to form flower buds is not close agreement with the carbohydrate nitrogen ratio. For example, a tree whose carbohydrate supply is low because of a heavy crop and whose nitrogen supply also is very low, may have the same carbohydrate nitrogen ratio as another tree of the same variety whose carbohydrate supply is exceptionally high, owing to lack of fruit on it and whose nitrogen supply is high yet the former condition is that most opposed to flower bud formation and the later that is most favourable. The necessary supplies of carbohydrates and nitrogen are much more important for flower bud formation than the ratio of carbohydrates to nitrogen.

The present position in regard to the physiological causes of flower differentiation is summed up from a horticultural view point by Gourley (1938) as follows:

"Other more specific substances are receiving attention as the primary casual agent of flower initiation and interesting evidence is at hand, but in any event it is in the green leaves or other green organs that these substances find their origin. The horticulturist need not at this time quibble over, nor greatly concern himself as to whether some hormone or flower promoting substance is more important than the food constituents in accomplishing the desired results. The fact still remains that flowers their end products—fruit and seed are composed largely of the products of photosynthesis and of organic nitrogen complexes. It is the green leaf, unharmed by insects, disease, caustic spray solution or other extremes of environment that tells the story."

"The suggestion does not seem improbabl

that under conditions favourable for the accumulation of starch in the tree some hormone, may accumulate and regulate flower bud formation. Such a hormone would be an organic compound possibly combined with nitrogen. Flower bud formation seems to be more closely correlated with the amount of leaf surface on the tree in proportion to the amount of wood-growth and fruit borne than with the accumulation of starch. Possibly formation of such a hormone is more closely correlated with the number and size of leaves of a certain age than is starch accumulation."

Reece (1949) working in Florida, gathered some interesting data, which show that something from the leaves that can move upward as well as downward in the phloem of the shoot stem can induce formation of flowers in buds, if their cells are dividing. This unknown substance is not formed in the mango-leaves throughout the year but only at certain times, autumn, winter or early spring in Florida, and it cannot cause inactive cell buds to begin cell division, can induce flower-initiation only in buds whose cells are dividing.

Loomis (1949) suggested that growth correlation in plants seems rather clearly to be associated with the action of growth hormones either in stimulating growth or in mobilizing and channelling the supplies of growth materials. In correlations between growth and differentiation in vegetative tissues, growth may be thought of as producing its own hormones and tending to monopolize the food supply. Differentiation is dependent upon the left over supplies of carbohydrates and hence is veg tatively correlated with growth.

Many workers have pointed out the dominance of apical buds in flowering. This may be attributed to the fact that shoots terminally located are in a fortunate position to receive elaborated food material due to polarity. An explanation of this is found in Leob's theory according to which growth takes place due to development of some hormones in the terminal position.

It was also reported that longer shoots are more prone to flower formation as compared to shorter shoots, but on the other hand highly vegetative or weak shoots remain barren. The explanation given by many workers is that the shoots of medium vigour, perhaps have a more favourable carbohydrate/nitrogen balance.

From the perusal of above account it can be concluded that there is some definite correlation between some growth features, such as leaf area, extension growth of shoots, position of shoots etc., and flower initiation phenomenon and the explanation for all this correlation rests with the proper and favourable nitrogen, carbohydrates balance, a condition most conducive for flower bud formation, with the assumption that some growth promoting hormones are also associated with the phenomenon.

IV. Summary

Numerous workers have mentioned the correlation between some vegetative growth features and blossoming.

For flowering, plants should be neither highly vegetative nor weak. Roberts (1926) working with apple. Anagostopoulos (1937) working on olive concluded that the trees with intermediate growth and medium sized shoots were in a favourable condition of floweing, perhaps due to having more favourable carbohydrate/nitrogen balance.

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IRRIGATION OF FRUIT ORCHARDS

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The proper and judicious irrigation of crops and fruit plants, is a problem of national importance. In view of the general shortage of irrigation water, we have to economize every drop of irrigation water. Irrigation of plants at right time and in appropriate quantity results in good growth and yields and thus ex essive water does not go to waste resulting in serious problem of water-logging.

It is an admitted fact that the vegetative growth, health, vigour and fruiting capacity of fruit plants is directly related with judicious irrigation. Water forms major portion of the body of plants. Further, all food nutrients are first dissolved in water before the roots can absorb and make use of soil ingredients. Water also helps in maintaining the turgidity of plant cells, and protect the plants from damage due to severity of high and low temperatures.

It is quite interesting to record that the farmers generally do not realize and know the importance and value of applying irrigation water of fruit plants—appropriate time, frequency and quantity. They do not feel it necessary to irrigate fully grown plants. No doubt, in case of older plants, where roots are capable of absorbing some quantity of moisture from sub-soil but it is not sufficient for normal bearing of fruit. At times, full care is not exercised while irrigating fruit plants, *e.g.*, excessive water goes too deep down far away from the reach of the roots and consequently it cannot be utilized by the roots. In fact, it does more harm by washing away the food nutrients from the soil. A farmer or a gardener should know that it is the small and thin rootlets, spread up to a depth of about two feet which are responsible for and capable of absorbing moisture and other food materials. These rootlets normally spread all around the tree according to the spread of the branches, rather these have got a tendency to spread some inches away from the spread of the branches.

Water Requirements of Fruit Plants

The quantity of irrigation water depends on many different factors *e.g.*, climate, temperature, rainfall, kind of soil, kind of fruit plants and age, intercropping and cover-crops sown in the garden, type of manure used and its quality, etc.

In hot regions, the quantity of water should be increased and frequency decreased so that sufficient moisture is available for transpiration. The severity and intensity of high temperature and the duration should also be taken into consideration while determining the water requirements of plants. During dry and hot weather, large quantities of water are transpired through leaves. The vegetative growth during the summer months is comparatively more. Accordingly more irrigation water is required during summer season.

It is generally possible to practise Barani fruit farming in places where the annual rainfall of about 25-40″ is available and is well distributed throughout the year. Artificial irrigation under such conditions through canals or wells in most of the fruit plants will not be necessary. It is recommended that garden sites should be selected near large bodies of water *i.e.*, river, canal, spring, lake or a big pond. It will help in providing sufficient moisture and humidity in the air and as a result, fruit plants can be grown with comparatively lesser irrigation.

By planting of strong wind-breaks on the direction of hot-winds, we can lower the water requirements of plants to an appreciable extent.

It is useful to plant banana plants at a distance of 5 feet around the budded or grafted mango plants. It will help in protecting the grafted mango plants from

hot-winds, sun-burn or frost injury. The clayey soils absorb and retain more quantity of moisture for a longer period as compared with loamy or light soils. It is, therefore recommended that in case of light soils, lesser quantity of irrigation water at frequent intervals should be applied. Heavy soils require more irrigation water though at long intervals. As vegetative growth is much more in clayey or heavy soils, such soils will naturally require more irrigation water.

In case of young plants, the quantity should be less but the frequency of interval should also be lesser as compared with older fruit trees.

Date-palm and banana need maximum quantity of water in comparison to other fruits. Guava plants do equally good under drought and excessive or heavy irrigation, accordingly this fruit tree can be successfully grown in flood affected and water-logged areas. Mango plants do not relish excessive moisture and irrigation water. The citrus fruit trees malta (sweet orange) sangtra, (mandarin orange), sour lime, grape-fruit, sweet lime, European lemon, etc., should be provided with sufficient irrigation water, so that the roots may get appropriate amount of air growth or de elopment and soil should be well drained.

Apples, quince, loquat, walnut and cherry fruit plants require sufficient moisture for growth and development. However, arrangements for the absorption, draining of excessive water should be made for normal fruiting and healthy growth. Plants like falsa, berry, olive and pear are quite hardy and drought resistant. Almond likes very dry warm light soils, and peach will do well in comparatively more wet and less warm soils. Apricot likes medium humidity and moisture as compared with peach. Plums can tolerate much heavier and moist soils in comparison with apricot.

Intercropping of fruit gardens, will naturally lead to more requirements of irrigation water for fruit plants. However, the quantity of irrigation water is dependent upon the kind of intercrops, its growing, spreading and fruiting habits and time of sowing and harvesting. All leguminous crops like persian clower (berseem) 'guara', all pulses and all vegetables can be successfully grown in the fruit gardens. However, it is essential to separately assess the requirements of the irrigation water for the intercrops and fruit plants. Likewise, it is also necessary to know the quantity and kind of fertilizer of manure applied to fruit plants for estimating the quantity of irrigation water. It is always recommended to apply irrigation water immediately after application of fertilizers, particularly in case of artificial manures like ammonium sulphate, super-phosphate and ammonium-phosphate, etc., otherwise the plants are liable to be adversely affected. In case, irrigation is not applied or delayed after manuring of fruit trees, the roots start absorbing water from the fruit plant itself for solution of food nutritions and thus the plant may die.

Time and Frequency

The time of irrigation mainly depends upon the capacity of the soil and sub-soil to retain soil moisture. Besides different fruit trees have different water requirements. Some plants will grow and bear fruit even under dry conditions. A simple method of estimating the needs and time of applying irrigation water is to observe the trees in the afternoon or evening hours. If the leaves are wilting in appearance it shows that the plants stand in need of water. If the soil is allowed to dry for a longer period, the leaves of the trees not only wilt in the evening hours but show wilting signs even during the next morning. It only proves that the life of the plant is at stake and in danger.

In wet soils where water remains standing for longer periods, the roots stop functioning due to lack of air and good nutrition like nitrogen, potassium and phosphorus and other mineral elements are not absorbed from the soil and consequently the plant may die.

It is evident that excessive irrigation is equally as harmful as drought. Special care should be taken in applying irrigation water to sweet orange, mandarin orange and mango plants. Sufficient interval between every 2 irrigations should be provided so that the soil becomes desirably dry. The fruit plants clearly give indications of water deficiencies. In case the new small leaves start wilting and turn yellow

in colour, it shows that excessive irrigation water has been applied.

Critical Stages

1. During flowering time of fruit plants, the quantity of irrigation water should be decreased otherwise the flowers are liable to shed but it may be noted that the soil should not be allowed to dry up completely. For instance in the plains the sweet orange sangtra and mango plants normally put on flowers during middle of March and fruit set is complete by middle of April. In the month of March only one light irrigation will be enough and in case of rain even one irrigation will not be required. After the fruit set, the first irrigation should be light and the second one normal as usual.

2. In order to avoid frost injury to fruit plants, it is advised to apply irrigation water during such nights when the frost is liable to occur.

3. In case, a shortage of irrigation water occurs during the hot months of May and June, it leads to fruit drop in heavy quantities. The rest of the fruit left on the tree generally suffer from granulation or is devoid of juice. The shortage of irrigation water not only leads to fruit drop, fruit injury and granulation but also the size of the fruit and leaves is adversely affected, and reduced.

The interval or frequency of irrigation water is dependent upon many factors. However, as a general rule, depending upon the kind, type and age of fruit plants, irrigation water should be applied after an interval of 8-10 days or with a maximum interval of 10 days during summer season. The quantity of irrigation water should be adequate. During the winter season, the interval should be enhanced to 2-3 weeks or even according to need to 4 weeks. During the rainy season, the interval will depend upon the rainfall—its quantity and frequency. In case of heavy rainfall, the excessive water should be drained out. During the months of October and November an interval of 4-5 weeks may be quite useful.

Methods or Systems of Irrigation

(1) Old Method of Channel System.

(2) Modified Channel System.

(3) Modified Basin System (Khal Kiari System).

(4) Flooding or Flood System.

(5) Basin System.

(6) Over-head Spray System.

1. Old Method of Channel System

In this system the plants are connected with each other by means of a straight narrow channel. This is the most indigenous, defective and old method of irrigation. It has got many disadvantages:—

(*i*) Water comes in direct contact with the stem or trunk of the trees. In this system only a narrow portion of the channel is irrigated, the roots are unable to spread on the sides. As such, the fruit plants irrigated by this method are less resistant and are easily affected by extremes of temperature.

(*ii*) The stem, by coming in direct contact with water, often starts roting or is attacked by different fungal diseases specially by "Collar rot".

(*iii*) Adequate amount of irrigation water and manure cannot be applied to the fruit plants.

(*iv*) All the fruit plants are liable to infection by one single diseased plant.

(*v*) The flow of the water is obstructed and adversely affected leading to loss and wastage of irrigation water.

(*vi*) It is not possible to apply desired quantity of irrigation water to every individual fruit plant.

2. Modified Channel System

It resembles in many respects with the first system. However, the basins around the plant are widened and increased in size to some extent. It has got the advantage that earthing up of the stems is possible and the roots spread over a larger area. But irrigation and manure cannot be applied in sufficient quantity in this system. However, all the defects given in the first system are prevalent in this system, but is comparatively improved method.

3. Modified Basin System (Khal Kiari System).

A straight long channel is made in between every two rows of fruit plants and a basin is made around every fruit plant according to the spread of the branches. Then every plant is connected with the main central channel running between every two rows of plants by separately. This system has got many advantages, some of which are given as under:—

(*i*) As the size and width of the basins is quite large, the roots spread all around, according to the spread of the branches. Consequently the plants become more hardy and can resist the extremes of temperature and drought.

(*ii*) The stems can be earthed up and as such are saved from rotting and infection by fungal diseases.

(*iii*) Irrigation water to inter-crops and fruit plants can be applied according to their requirements and at adequate intervals, rather it is essential to adopt this system of irrigation in case intercropping of fruit garden is to be carried.

(*iv*) It leads to economy of irrigated water.

In view of these facts this is the best method of irrigation for the young plants.

This system has got some disadvantages:—

(*i*) It is quite expensive to build and make channels every season, or after sowing intercrops every time.

(*ii*) The channels may be broken during interculture and ploughing operations.

In order to remove these defects, it is recommended that vegetables may be grown as intercrops in the garden. In case of other crops the seeds may be sown and then the channels be made. However, while making a selection of different intercrops, it is recommended that the availability of labour, manure of fertilizer, irrigation water and marketing facilities should be taken into consideration and in no case the intercrops run in competition with the fruit plants.

4. Flooding or Flood System

When the fruit plants get older, attain full size and maturity, spread and start fruiting, generally no space is available in the fruit garden for sowing of intercrops. The branches spread on all sides and cover the whole area in the garden. In that case it is not advisable to maintain the basins but it is recommended that flooding or flood system should be adopted. Besides when crops or vegetables are grown in the garden, this sysem is also advantageous.

In this system all the cultural operations *e.g.*, ploughing, cultivation, hoeing manuring, pruning, and spraying of fruit plants can easily and effectively be performed. This method has got another advantage *i.e.*, the roots and rootlets can get sufficient area for spread to full capacity on all sides.

5. Basin System

When the fruit plants are young in age, the area of the garden is not very big or the plants have been planted in the form of a kitchen garden over a small area. Basin System of irrigation is recommended. In this case basins are made around the plants according to the spread of the branches by means of a watering can, a bucket or a water skin. No doubt this is an expensive method but it economized irrigation water. However this system of irrigation cannot be recommended in case of big gardens nor is it possible to practise it.

6. Over-head Spray System

Irrigation water is carried to the garden by the use of metal pipes and then is sprayed on the leaves and branches over the head of the plants. This system has got some advantages. Water is economised, excessive water unlike other systems of irrigation is not wasted by run off. However, it is not commonly practised in Pakistan as it leads to heavy expenses in laying out of the irrigation pipes, and spray system.

Some Precautions

1. In case of excessive irrigation, the ripening of the fruit delayed and the fruit is comparatively of poor quality.

2. Excessive irrigation leads to too much of vegetative growth, resulting in little or no fruiting. It leads to the problem of alternate

bearing or scanty fruiting habits of fruit trees.

3. In case irrigations are delayed at frequent intervals till the end of autumn season, the fruit plants continue putting on new vegetative growth. As a result less resistant fruit plants are subject to frost injury during the winter season.

4. Excessive irrigations at frequent intervals are liable to bring fungal diseases for the fruit plants.

5. The stems or trunks of the plants should be earthed up in order to avoid direct contact of irrigation water and thus save the plants from the attack of fungal diseases, particularly the "Collar rot".

6. The irrigation channels and water courses should be straight, clean well-levelled and free of weeds and grass so that irrigation water may flow easily without any obstruction. Irrigation should always be in adequate quantity, at right time and right intervals.

7. The level of the fields should be kept quite even, specially, when the flood system of irrigation is practised otherwise it will be quite difficult to apply adequate quantity of water to all the plants. It has been noticed that by frequent use of furrow turning ploughs or too frequent cultivation by the use of indigenous or Desi plough, level of the soil is often disturbed, rather a small ditch is formed in between every two rows of fruit plants and consequently fruit plants cannot make full use of the irrigation water. It is, therefore, recommended that dragging or "Sohaga" should be regularly and invariably used after ploughing or cultivation.

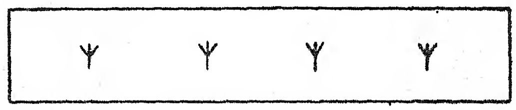
8. The fruit plants remain stunted in gowth and present a sickly appearance, if sufficient amount of irrigation water is not given.

9. In case, irrigation water is not available in sufficient quantity, the distance between the fruit plants should be enhanced so that the roots may absorb moisture from a longer distance. Besides the plants can be irrigated by use of watering can or buckets. This system is advantageously used in case of young fruit plants, over a small area.

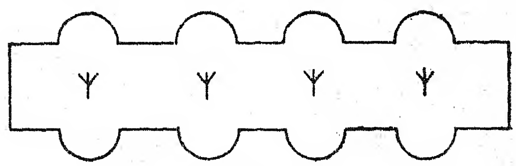
10. It is always advisable to divide the bigger fields into smaller plots for irrigation purposes, otherwise the irrigation or rain-water will wash and erode the soil-nutrients and the soil itself.

11. The basins of the fruit plants should be continuously widened and increased in size, according to increase in the spread and size of the branches.

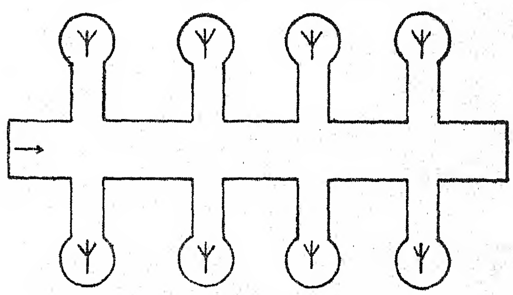
IRRIGATION OF FRUIT PLANTS:
DIFFERENT SYSTEMS



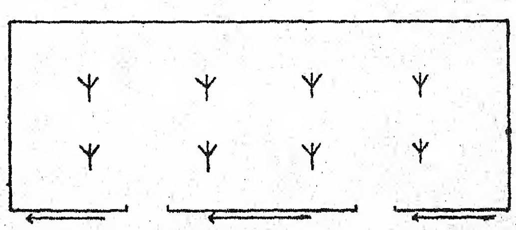
System No. 1.
Channel System or Old Method.



System No. 2.
Modified Channel System.



System No. 3.
Modified Basin System (Khai Kiarl System).



System No. 4.
Flooding or Flood System.

CULTIVATION OF MUSK-MELON IN WEST PAKISTAN

BY

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Musk-melon is a popular summer vegetable and is grown annually on an area of about 60,000 acres in West Pakistan. It is a good source of vitamins *viz.* Vitamin A 2,000 international units, Vitamin B_1 19 international units, Vitamin B_2 30 sherman units and Vitamin C 37 milligrams per 100 grams of edible portion. It also contains sufficient quantities of all the essential minerals *i.e.* calcium 0.24%, phosphorus 0.21%, potassium 4.62% and sulphur 0.01%. The seed has also got great nutritive value and is used as medicine.

Climatic Conditions.—The musk-melon thrives best and develops the highest flavour in a hot dry climate. In West Pakistan a large part of the crop is sown in arid and semi-arid regions under cultivation. In humid regions foliage diseases are specially serious and if the weather is cloudy and rainy during the ripening season, the fruits do not develop the best quality. High temperature and sunshine seem to result in best quality.

Soil and Soil Preparation.—Musk-melons are grown on a variety of soils from the sand and sandy loam to the silt loam and clay loam. Where earliness is important a sandy-loam soil is considered excellent. In fact this class of soil is considered almost ideal in most producing areas. Any well-drained soil is satisfactory provided other conditions are favourable. Well rotten farmyard manure should be added one month before the sowing at the rate ol 24 tons per acre. The soil should be wel p epared. In some areas land is prepared for planting on ridges 5′ apart or the seed may be sown on flat 5′ from row to row and 2′ from plant to plant. The flesh and seed in musk-melon removes large quantities of nitrogen from the soil. It has been experienced that the crop may be supplemented with $1\frac{1}{2}$ maunds of ammonium sulphate at the time of flowering. Where the crop is sown on ridges, it is immediately watered after sowing. Care should be taken that the water does not overflow the ridges. In flat sowing the field should be in proper 'Wattar' that is sufficient moisture to promote proper germination of seed.

Sowing Time.—Musk-melon plants are very tender and the seeds will not grow at lower temperature. Hence sowing of seed should be delayed until the danger of frost is over. The crop is usually sown in the month of February and March.

Cultivation.—Frequent shallow cutivation *i.e.*, weeding and hoeing should be given until the vines have become sufficiently long. Turning away of vines from one place to another seriously injures them and it must be avoided in hoeings. When the vines have attained sufficient size, large weeds may be pulled by hands. Usually three hoeings are considered appropriate.

Seed Rate.—Two seers of seed is sufficient

for planting one acre. It does not matter whether it is sown on ridges or flat.

Irrigation.—The musk melons requires very light irrigation. The duration and interval of irrigation depends on the kind of soil, cultural practices followed and general climatic conditions. In the early stages irrigation interval may be 10-12 days and later this pariod is extended from 16-20 days.

Yield.—The fruits are ready for havest from May to June and the crop normally yields 250 maunds per acre.

Varieties.—The type of musk-melon which has a hard rind is much adapted to long transportation. Of course it must have good flavour, texture and sweetness. The Vegetable Section at the Punjab Agricultural College and Research Institute, Lyallpur has evolved certain varieties by selfing and intervarietal hybridization. The most important varieties recommended to growers are C194 & C96.

Variety C194.—The fruit is of yellow green colour with green stripes and the flesh is light green with refractive index 7%.

Variety C96.—The fruit colour is yellow with green stripes. The fresh colour is orange with refractive Index 8 to 9%.

Control of Diseases and Insect Pests.—Knowledge of control measures for important diseases and insect pests is essential to successful vegetable growing. Both diseases and insects are becoming more serious owing to the concentration of vegetable crops in most favourable areas for production. New pests appear from time to time because of the changes in the cultural practices or in cropping scheme which may then favour their development to injurious proportions or they may be introduced from other areas. The grower must be able to identify common insect p sts and diseases and should learn the methods of plant protection. Pests and diseases greatly reduce the expected yields and the price goes up because of short supply. While the grower applies the control measures, the ultimate consumer pays for the cost of the diseases and insect control. A reduction in quality of produce may also result from diseases and insects. Excessive damage lowers the grade and price and may even result in rejection of the produce by the buyers. Disease and insect control is one of the most important factor in successful production of musk-melon crop.

Control Measures.—Insect of many kinds pass the winter season in the refuse left on the fields. If this is ploughed under, most of the insects die but the diseases that live over winter on plant remains are not destroyed by ploughing. Some insects pass the winter in weeds or trash lying around the fields, therefore, cleaning up of these places is essential. Many of the virus diseases over winter in the roots of perennial weeds. Destruction of these weeds is essential.

The important insects that feed on musk-melon crop are Epilachna beetles and fruit fly.

Epilachna beetles.—These are probably the most serious insect pests of musk melon. These attack the plant as soon as they emerge, devouring the leaves and eating in to the stem. The main injury is done by over-wintering adults that attack the young tender plants. The beetles also carry the bacteria of cucumber wilt but the larvae burrow in to the roots and cause the plants to die. The pest can be controlled by spraying 0.4% D.D.T. or dusting with 0.75% Rotenone. The treatment should be repeated once or twice a week as long as the beetles are present.

Fruit flies (Dacus cucurbitae).—This is the most destructive pest and its control has become the limiting factor for successful cultivation of this crop. Maggots which emerge from the eggs laid by the females, feed on the pulp of the fruit causing decay and thus redering it unfit for human consumption. The attacked fruit is malformed, misshaped, often rots and drops down. The pest can be controlled by spraying the crop in the early stages with 0.2% Dieldrin (1.8 IB a.m. per acre) or 0.05% Endrin (0.48 IB a.m. per acre).

The important diseases are Downy Mildew and Powdery Mildew.

Downy Mildew.—The disease is caused by the fungous pseudoperonospora cubensis and is a major disease of musk melon. The disease develops rapidly in moist warm weather. It first appears as grey tinged

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CULTIVATION OF POTATOES IN WEST PAKISTAN

BY

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Potato is the most important food crop of the world as regards total production and is extensively cultivated in cold countries particularly Europe and Northern parts of the United States of America. It is interesting to note that its original home is South America where it grows wild and an extremely large number of its species and varieties are found to grow under natural conditions but its importance as a high yielding food crop has been realized more by the advanced countries of the world than the comparatively less developed South American States.

It is a matter of great interest that three crops of potatoes can be raised in the province of West Pakistan as against one or two in countries where it is grown on extensive scale. These three crops can be raised one after the other in a year *viz.*, the summer crop in the hills from April-May to September-October and autumn and spring crops in the plains from September to January and January to May respectively. It is very surprising that in spite of nature's gift of providing weather conditions in this province which permit growing of potato all the year round in this province, its area and production have remained extremely low. There is a large number of factors responsible for keeping the area and production under potato low but the main obstacle in this direction has been the lack of scientific knowledge of the subject as well as absence of efforts to push the potato crop amongst the growers with the desired zeal.

Potato gives very encouraging yields as well as high monetary returns in West Pakistan. After the independence, the area under potatoes has increased considerably and production per unit area has almost been doubled. Prior to partitioning of the country, table and seed potatoes worth several lacs of rupees, used to be imported from the territories now forming part of India. It is on account of the efforts of the Agriculture Department and the growers that Pakistan has become self-sufficient in the matter of table and seed requirements of potatoes.

The country is facing an acute food shortage and the Government is importing wheat from foreign countries at a cost of several crores of rupees. This problem can very effectively be tackled if the production of potat es is increased substantially. It is estimated that the per capita consumption of potatoes in our country is about 5-6 seers as compared to 2-3 mds. in the Europe n countries and the United States of America. It is probably due to the fact that potatoes are mainly used as pot herbs in our country whereas they are consumed as source of energy in the advanced countries of the world.

Although the production of potatoes has been doubled in this province after the independence yet they are not sufficiently cheap. Efforts are required to be made to increase their production so that they reach within the means of common man.

Some of the important results of the experiments conducted in the Vegetable Section, Lyallpur are given below for the guidance o: the growers:

1. *Time of Sowing.*—The summer crop

is sown in the higher hills in the months of April-May and harvested in September-October. The spring crop of plains is planted in January and harvested in April-May while the Autumn crop is sown in the plains in September-October and lifted in January.

2. *Seed Procurement.*—(A) Previously the seed for raising the spring crop used to be imported from India at a huge cost but now seed from the harvest of summer crop of Murree, Hazara and Quetta is being utilized successfully. This experiment has met a great success and no seed is being imported from India for the last 5-6 years and, in this way, 8-10 lacs of foreign exchange are annually saved.

(B) Prior to independence, seed potato worth 50-60 lacs of rupees used to be imported from Patna but now the province is self-sufficient to meet this requirement. Seed from the produce of spring crop is kept in the cold storages and used for raising the autumn crop.

There were only two cold stores in this province at the time of partitioning which have now reached 50-60 in number. Only table and seed potatoes, Malta and other fruits are kept in the cold stores and the country is saving crores of rupees.

3. *Seed Rate.*—The experiments have shown that the bigger sized tubers, thickly planted, give very high yields. With the installation of cold stores, the rate of keeping the potatoes has reduced considerably and the growers have gradually started growing big tubers. One bag per kanal is considered to be the best seed rate. Some people even use 1½ bag per kanal. Small sized tubers and less seed tells upon the yields adversely. Fresh experiments have revealed that if the big tubers are cut in halves after taking out of the cold stores in the middle of August and immediately placing back in the cold stores, a layer is formed on the cut surface and they can be successfully sown after a month. In this way a considerable saving in the seed potato can be made without affecting the yield of the crop.

4. *Method of Sowing and Irrigation.*—The best method for the cultivation of potatoes is to apply 30-40 cartloads of well-rotten Farmyard Manure per acre and then pulverised thoroughly. If the water is available it should be given to the field. When the field becomes on 'Watter' condition it should be again ploughed thoroug .ly. In the canal colonies the field be divided in eight parts and furrows should be opened at two feet apart. In the well irrigated area the plot should be half a kanal. After placing the seed tubers in the furrows at a distance of 5″ to 7″ from each other they are earthed up with the help of 'Jandras' and irrigation should be applied in 1 2 days' time. The potato crop should be watered after every 5-7 days.

5. *Interculture and Earthing up.*—Potatoes complete their germination in 4 to 6 weeks time. The first hoeing should be done after one month and weeds etc. cleaned. When the plants are 5″ to 6″ high, the soil should be thoroughly pulverised and earthing up be done. If Ammonium Sulphate is applied under the plants at the rate of two bags per acre before earthing up, the yield increases substantially. Strict care should, however, be taken that the fertilizer does not fall on the leaves otherwise it shall burn the plants.

6. *Yield.*—The autumn crop yields about 150 maunds to 250 maunds of tubers per acre which give an income of about Rs. 1500 to the growers. The yield of the spring crop is comparatively less and gives 80 to 150 maunds of potatoes.

7. *Varieties.*—Varieties Phulva and Surkha were common in this province at the time of partitioning. After the independence, the Agriculture Department gave out avariety known as Factor (Kohala) which spread in the province very speedily. This variety gave much higher yields than the old varieties and gave more income in view of its earliness. The Vegetable Section of the Department of Agriculture has now selected another variety namely Ultimus. This variety has red skin and is as good from cooking point of view as in yield. It produces about 25 to 50 maunds more tubers per acre than the variety Factor. Large quantities of variety Ultimus are imported from Europe for distribution amongst the growers every year.

8. *Diseases and Calamities.*—Frost is the greatest enemy of potatoes in West Pakistan. In the days of severe cold when the water

freezes, potatoes are very badly damaged. This generally happens in the mid of December or beginning of January. Similarly more heat is also not desirable for the cultivation of potatoes.

Two insects namely Cut-worm and Aphids damage the potato crops. Cut-worm eats up the leaves and tubers while the Aphids suck water from the leaves. The attack of these insects is severe in the spring crop. As soon as the tubers start growing in thickness, D.D.T. or Gamexin should be mixed in ash and dusted on the plant. The Cut-worm comes out in the night and dies when it comes in contact with the insecticide. Aphids are not as harmful to the standing crop as they are to the next crop. If the spray of D.D.T., Diendrin or Endrin is made one or two times in the potato crop in the month of April, the crop raised from such seed shall be free from diseases.

A fungal disease known as late blight often results in a severe damage to the potato crop of hills. In order to control this disease the crop should be sprayed with Bordeux Mixture two to three times.

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spore masses on the older leaves causing small angular yellow spots which incr ase in number and size. As the older leaves begin to die, the disease begins to appear on younger leaves. Los of foliage results in low set of fruits and poor quality. The spores spread by winds, insects like Epilachna be tles or by splashing rains. Ploughing unde of diseased vines immediately after harvest is the recommended practice, but the principal control measure is of thorough application of fungicides, sprays or dust once a week with Zerlate 1½-2 lbs in 100 gallons of water per acre.

Powdery Mildew.—The casual fungus is Erysiphe chicoracearum which grows on many kind of plants besides musk melon. The disease affects the leaves and stem. The disease first appears as round wide spots on the underside of the older leaves. The spots enlarge, increase in number and eventually cover both surface of the leaves with a powdery growth. The leaves become chlorotic and make poor growth and the plants may be killed. Fruits of musk melons on infected vines ripen prematurely and lack good texture, flavour and sugar content. The disease can be controlled by spraying sprsul 1 lb. in 100 gallons of water per acre.

STORAGE OF VEGETABLES

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Vegetables have been an essential part of human food since ages. They are generally consumed in a fresh condition, but they cannot be kept fresh after they are removed from the field longer than a few hours. There is sometimes glut in the market but very often there is a great shortage of these particularly out of season as well as in the centres of consumption located at a long distance from centre of production. We are lucky to have sufficiently good transport system of road and rails at present and we very often see truck loads of fresh vegetables moving from one part of the province to another part over distances as long as two hundred to five hundred miles. Cauliflower, watermelons and muskmelons are almost always transported from the specialized centre of production to other parts of the Province in this manner.

There are, however, still great limitations in the use of this method in the way of high cost of transport as compared to the price realized from the sale of these vegetables. To overcome these difficulties and to make vegetables available for consumption, it is a great ambition of the people to get a vegetable on the table when they feel like consuming it in this part of the country as in other parts of the world. To realise this ambition of the consumer and to make more returns from the cultivation of different vegetables, the following methods are being followed in different countries which will serve as a sort of guide for the growers and the consumers of this country.

1. Dehydration

Dehydration of vegetables particularly of Methi, Turnip, Palak, Karella and Cauliflower is in progress and has been practised on commercial scale since long. So far this has been done by method of simple sundrying. The work carried out in other parts of the world as well the Agricultural College, Lyallpur, has revealed that by use of mould killers like sulphur, boiling at particular temperature and dehydration under controlled conditions can be followed in case of above mentioned vegetables more hygienically as well as some other vegetables like potatoes, carrots, almost all the leafy vegetables particularly coriander and brassica leaves and flower stalks. The vegetables dehydrated properly can be stored for quite a long period without recurring any cost. The only disadvantage sometimes is that these do not taste like fresh vegetables but that is not an important shortcoming.

2. Preservation in salt

Certain vegetables like peas, beans, tomatoes etc., are being successfully preserved in the European countries in their natural form in low concentration of salt and are being extensively used all the year round as the nature is not very kind to them in the way of providing varying climatic conditions throughout the year as in Pakistan. There is no reason why these and such other vegetables preserved in high concentration of salts which is a part of human diet and can prevent growth of mould, should not be employed on extensive scale to make vegetables available for consumption in any part of the country at any time in the year. The only disadvantage of this method is that it can be followed successfully after a little training under the technical staff.

3. Preservation of vegetables at low temperature

Almost any plant or animal body can be preserved for long periods whether the tissues are in living condition or dead form. A crude method of preserving food like fish, meat, milk and its products has been and is being still followed extensively through the use of ice, but it is far from being hygienic and ideal. A more recent and now extensively used method is to preserve vegetables like potato, fruit, fish, milk, etc., is through the use of Cold Storage Plants which are working very successfully in Karachi Port for preserving fish.

There were only two Cold Storages at the time of independence in vast upcountry area of West Pakistan at Lahore and Sialkot. Actually more than ninety-five per cent of their space was utilized for preserving seed potatoes. Now due to spectacular increase in area under potatoes after independence, a substantial increase in Cold Storage number and Cold Storage space has occurred. The number of Cold Storages has gone from two to sixty and the Cold Storage space from about 60,000 maunds in 1950 to about 5,00,000 maunds in 1961. Out of this Cold Storage space about two third is used for preserving seed potatoes and the rest for ration potatoes. A few hundred maunds of oranges and plums are also stocked. All the Cold Storages working at this time are designed in such a way that they have three to five big rooms which run at a temperature of 35°F to 45°F under normal condition and a humidity of 80 to 85 per cent. There is no law in the country to control the designs, chamber size, flow of air, automatic control of temperature, humidity, etc., of these cold storages with the result that majority of them are not properly designed and are worked under inefficient management. Even in these cold storages working under the present conditions there is a huge scope of preserving vegetables like carrots, turnips as well as chewing sugar cane with great advantage to both the producer and the cold storage industry.

The time has come when the cold storage industry of the country should further expand and remodel itself to run on scientific lines so that the perishable articles like vegetables, fruits, eggs, fish, milk and milk products can be preserved in an ideal way. For this purpose the storages may run chamber of smaller sizes but more in number in different blocks where controlled temperature, humidity, air flow, etc., can be maintained at will as the case is in the advanced countries of the world.

A systematic experimentation is necessary to work out proper temperature, humidity, size of chamber, flow of air and the machinery to work the same efficiently but till that is done, it will be of interest to the people of this country to know the results of such experiments carried out in the advanced countries of the world and utilized commercially to the advantage of producers and consumers. The following chart showing the proper temperature, humidity as well as the period for which different vegetables can be stored is given for the information of all interested in the subject:—

Commodity	Temperature Degree F	Relative Humidity %	Approximate length of storage period
1. Cauliflower ...	32	85-90	2-3 weeks
2. Cabbage ...	32	90-95	3-4 months
3. Cucumber ...	50-60	50-85	6-8 days
4. Egg plants ...	50-60	85-90	10 days
5. Lettuce ...	32	90-95	2-3 weeks
6. Watermelon ...	50-55	75-85	2-3 weeks
7. Muskmelon ...	32-34	75-85	1-3 weeks
8. Onion ...	32	70-75	5-6 months

[contd.

	Commodity		Temperature Degree F	Relative Humidity %	Approximate length of storage period
9.	Potato	...	36-40	85-90	1-3 weeks
10.	Pumpkin	...	55-60	70-75	2-6 months
11.	Radish	...	32	90-95	2-4 months
12.	Spinach	...	32	90-95	7-10 days
13.	Sweet Potatoes	...	50-55	80-90	4-6 months
14.	Tomatoes Ripe	...	50-55	80-85	7-10 days
	Green	...	50-60	80-85	1-6 days
15.	Turnips	...	32	90-95	2-4 months
16.	Beets	...	32	90-95	1-3 months

It is hoped that by utilizing the information given above, the people of means who can afford to instal Cold Storages, can carry out profitable business and also benefit the agricultural industry of the country considerably.

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Vegetable Crops by Homer C. Thompson and William C. Kelly.

BREAKFAST CEREALS

By

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1. Introduction

Cereals have been the stuff of life since ancient times. With the passage of time man learned more and more how to make efficient use of cereal grains for human consumption. Cereals were therefore split into various categories in the order of taste preferences particular for a certain community, tribe or a class of people inhabiting different areas across the world. Similarly man developed various refined foods from cereal grains through the use of scientifically planned processing techniques and this was not the end of the story. Cereals were further classified into definite groups so as to allure the human aesthetic sense at various functions throughout the year or even for various meals during the same day. In certain countries, breakfast foods constituted the entire morning meals while bread predominated at other meals during the same day. It is here that breakfast cereals have come into play.

Breakfast foods form a principal portion of the meal served early in the morning which consists of products made from basic cereal grains like wheat, rice, corn and oats. Due to economy of cost and time breakfast foods have offered promise for use in the morning meal.

The importance of breakfast cereals was early recognized and their commerical manufacture started first in the United States in the beginning of the twentieth century. Today it is a promising industry in U.S.A. and their demand is expanding tremendously in U.K., Canada, and Pakistan.

According to latest statistics[4], 1.25 billion pounds of breakfast cereals valued at £103,000,000 were produced in U.S.A. in the year 1950. A Cereal Manufacturing Products, Ltd., Rawalpindi has been established in Pakistan and is producing breakfast cereals like corn flakes, wheat toasties, rice crunchies and also puffed cereals since 1957. This gives a fair idea of the wide popularity of these preparations for the diet of their people and it therefore becomes all the more imperative to throw some light on various aspects of their preparation, composition and current research which is the main aim of this paper.

2. Types of Breakfast Cereals

There are quite a variety of breakfast cereals now appearing on the table every day and it is advisable to split them into categories so as to facilitate their proper understanding. In U.K., U.S.A. and Canada, breakfast cereal foods have been divided into the following two classes.[4, 6]

(*a*) Breakfast cereals which need to be cooked before consumption.

(*b*) Breakfast cereals which can be consumed in the form in which they are purchased from the grocery store.

As far as the first category is concerned, only prepared oats suitable for making porridge are generally available. Regarding the second category, breakfast foods have been prepared from wheat, maize, rice and oats. They are eaten with either milk or a tinned fruit. They are also sweetened and flavoured with various agents like malt extract, syrups, cane sugar, glucose and honey. The raw material employed for the preparation of the above categories of breakfast foods include common cereals and mixtures of different cereals such as corn meal, rolled oats, cracked wheat and farina.

Ready to serve cereal breakfast foods may be conveniently classified into two general types:

1. Those made from entire grains or their mill products.
2. Those made from fabricated cereal products.

Both of the above types are found on the consumer market in the form of flaked, shredded, granular, puffed and toasted breakfast foods. There is quite a large variation between each type in regard to cereals employed, amount and kind of cooking and the flavoring used. In the following lines a very brief description of the methods employed for the manufacture of each shall be given.

3. Methods of Manufacture.

Methods of the manufacture of breakfast cereal foods shall be discussed briefly according to the categories mentioned above:[4, 6]

(*a*) Oat-meal is the main cereal thus far utilized for the purpose of this category and its preparation is very simple. Oats are graded into various sizes, sent to hulling stones where the hulls are separated from groats by impact hullers. Partially milled groats and oat flour are separated on sieves. Oat groats are further processed for the preparation of rolled oats while oat flour or meal are employed as a breakfast cereal.

(*b*) Breakfast cereals which are cooked and ready to serve are given below:

(1) *Flaked breakfast foods.*—They are commonly prepared from maize, wheat and rice. Maize flakes are prepared from corn grits while wheat and rice flakes are prepared from grain. The method employed for each is basically the same except that in the case of corn flakes, corn grits are used instead of grain. For wheat and rice, grain is cleaned, conditioned, cracked, cooked and other ingredients as sugar, malt and salt are added at this stage. The cooked cereal is dried to a moisture content of 15-20% and then it is allowed to lie in a bin until it has become suitably conditioned. The duration of this conditioning process varies—it is 24 hours for wheat and maize but 72 hours for rice. The conditioned material is sent to flaking rolls and flakes passed through toasting ovens. The toasted flakes are conveyed to a cooler and then to a packing bin. Dust and broken flakes are removed either during toasting or at the cooling stage.

(2) *Puffed breakfast foods.*—Wheat and rice are commonly employed for the preparation of this category of breakfast foods. The principle of the puffing process is to heat the cereal in a pressure chamber until a pressure of 100 lbs. or 200 lbs. per square inch has been built up and then to release instantaneously this pressure by suddenly opening the pressure chamber or the puffing gun as it is called[1]. The expansion of the water vapour which occurs when the pressure is suddenly released, blows up the grain to several times their original size. Grain is cleaned, run into the puffing gun, steam is then introduced, gun heated externally until a pressure of 200 lbs. per square inch has been attained when the gun is fired. The puffed grains are toasted to a moisture content of about 3%.

(3) *Shredded breakfast foods.*—Another form of ready to serve breakfast food made from whole wheat is the shredded breakfast food which takes the form of tablets composed of long shreds of cooked and toasted wheat. Grain is cleaned, cooked in a pressure cooker, cooled and stored in a bin for conditioning. The conditioned product is conveyed to shredders which consist of pairs of rolls, one of which is smooth while the other bears

circular grooves on its surface. Wheat is forced into rolls and cut into long shreds that fall on to a conveyor. Shredders are so arranged that layers of superimposed shreds are obtained. The layers of shreds are cut into tablets by knives and transferred to baking pans. The pans pass to a revolving oven and bake for 20 minutes at 500°F. The baked tablets are dried and cooled.

(4) *Granular breakfast foods.*—The only difference from the above method is that breakfast cereals are prepared from a fermenting dough. Dough is made from a mixture of long extraction flour, malted barley flour, yeast and salt. The dough is fermented for about 5 hours at 80°F.

When considerable diastatic action has taken place, the fermented dough is baked into large loaves which are disintegrated and dried. The dried material is ground and sieved to a standard granularity.

4. **Composition of Breakfast Cereals**

Breakfast foods differ widely in chemical composition depending upon the nature of the raw material and the method employed for their manufacture. It is surprising to find that very little research work concerning such foods has been conducted to investigate the quality variations from locality to locality. However Kent-Jones and Jacobs[4, 6] have given a short data on the composition and fuel value of different breakfast foods which are presented in Table I. In Table II are given detailed figures on the mineral and vitamin contents of some common categories of breakfast foods. Chemical composition of cereals is self-evident and needs no further discussion.

It has been observed that certain prepared breakfast foods contain lesser quantities of minerals and vitamins as compared to their natural contents in the respective raw materials due partly to the processing treatments to which they are subjected. Hence it is customary to add certain minerals and vitamins depending upon the nature of the deficiency observed. For example, in the preparation of "Cheerios" minerals like Ca, Mg, Fe are added in sufficient amounts to compensate for the use of non-cereal ingredients in the formula and thereby meet the claim of whole grain levels.

TABLE I

Chemical Composition and Fuel Value of Some Common Breakfast Foods

Name of Food	Moisture %	Ash %	Protein %	Fibre %	Carbohydrate %	Fat %	Cal/100 gms %
Corn Flakes ...	4.3	3.1	8.0	0.4	83.9	0.3	370
Rolled Oats ...	10.5	1.8	17.4	1.2	62.8	6.3	378
Cream of Rice ...	11.8	0.5	7.4	0.3	79.6	0.4	352
Puffed Rice ...	9.0	0.4	6.0	0.4	83.9	0.3	363
Rice Crispies ...	5.4	3.3	6.8	0.3	83.9	0.3	366
Cracked Wheat ...	12.7	1.7	9.6	1.9	72.1	2.0	345
Cream of Wheat ...	11.6	0.4	12.6	0.2	74.5	0.7	355
Wheat Crispies ...	6.5	4.3	8.8	1.8	77.4	1.2	356
Muffets ...	10.4	1.6	10.3	1.7	74.7	1.3	352
Wheaties ...	7.1	4.7	13.2	1.4	72.5	1.1	353

In the preparation of cereal breakfast foods from whole grains where high temperature and long cooking operations are employed, the thiamine content is partially destroyed. It is accordingly necessary to restore this vitamin if claims of whole grain or natural level are made. Similar is the case with riboflavine and niacin.

B_1 as soon as cooking operations have been performed.

The same authors have pointed out that ready to serve breakfast foods are often consumed in admixture with about half their weight of milk. Since the sugar contains no B_1 and the milk contains very little, the breakfast foods sholud contain sufficient to deal adequately with the metabolism of the mixed dishes. On the basis of that 0.18 I.U. of B_1 are required for each nonfatty calorie intake, the cereals should have a B_1 content of 0.9 I. U. per gram. If, therefore, a breakfast food it fortified with B_1 so that it regained the original B_1 level of the cereal from which is had been made, it would in most instances contribute more than the required amount of B_1 for each nonfatty calories of the cereal, sugar, milk, meal.

TABLE II

Mineral and Vitamin Content of Some Categories of Breakfast Cereal Foods

Name of Food	Mineral Elements per 100 gms				B-Vitamins per 100 gms		
	Ca Mgs	P Mgs	Fe Mgs	Cu Mgs	Thiamine Mgs	Riboflavine Mgs	Niacin Mgs
Corn Flakes ...	10.0	56.0	1.0	0.17	0.16	0.08	1.6
Rolled Oats ...	54.0	365.0	5.2	0.50	0.55	0.14	1.1
Rice Flakes ...	9.0	90.0	0.9	0.56	0.05	0.03	1.4

5. Research on Breakfast Cereals

Very few references are available on the research work conducted so far on various problems connected with breakfast cereal foods. It is the opinion of the author that no elaborate research review could thus be cited. It is worthwhile to mention salient points of the experimental work conducted on breakfast foods, however little they may be.

Slater and Rial[7] showed that heat treatment to which the cereals were subjected during the preparation of ready to serve breakfast foods often destroyed over 90% of the original B_1 content. Jackson, Doherty and Malone[5] confirmed that during the production of puffed and flaked cereals, the destruction of B_1 was almost complete but the former authors found that 50% of the original B_1 might survive in shredded wheat. This may be explained by the use of less severe cooking and baking treatments in the preparation of shredded cereals.

Booth et al found that vitamin B_1 was usually insignificant in flaked and puffed cereals whereas the riboflavine and nicotinic acid contents were in the region of those expected in the grain from which the breakfast foods are enriched with vitamin

Cereals contain phytic acid—a compound which may interfere with the absorption by the body of calcium and iron in the diet, but this is hydrolysed during the manufacture of breakfast foods, extent of hydrolysis depending upon the method of processing, the greater the pressure under which the cereal is cooked, the greater the destruction of phytic acid. It has been found that 70% of the phytic acid was destroyed during the manufacture of puffed cereals and 33% during the making of flaked cereals.

Cereal Institute of America[8] investigated the role of breakfast foods as far as they affect the efficiency in the late morning hours. This was assessed experimentally from the diet regimen involving 70 different

subjects lasting over a period of six years. Their findings in brief are given below:

(1) Omission of breakfast results in poor attitude towards school work and detracts attention from scholastic attainments.

(2) Basic breakfast was defined as one providing one fourth the daily protein allowance which is superior in maintaining efficiency in the late morning hours when compared to either the larger or smaller morning meal.

(3) Omission of breakfast not only accentuates the hunger but also suffers a significant loss of efficiency in the late morning hours.

(4) An adequate "breakfast" designated as basic breakfast has been established. A basic breakfast has been defined as one which provides for the one fourth of the total daily calories requirements and one fourth of the total daily protein allowance. This has been designated as a guide by which a nutritionally adequate breakfast can be calculated for any individual by adjusting it both caloriewise and as to the protein allowance. This adjustment is made on the basis of nutritional requirements necessary to maintain any desired nutritional level.

Felt et al.[3] conducted studies on the determination of the shelf life of packaged cereals by comparison of calculated and observed shelf life values. These workers found that the shelf like of a packaged cereal varies widely depending upon the season, the locality and the hygroscopic properties of the product itself.

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AUREOMYCIN AND TERRAMYCIN

BY

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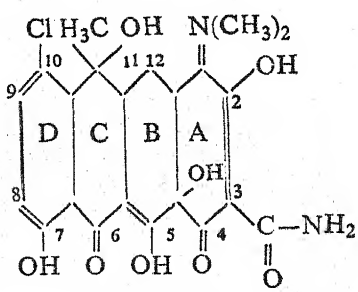
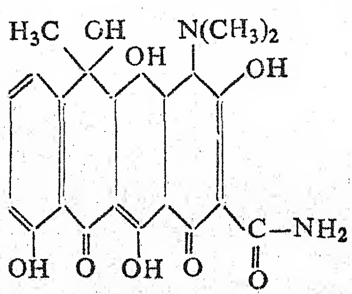
1. Fundamental Aspects

Aureomycin and Terramycin are biosynthesized by the species of microorganisms known as streptomyces. Both of these antibiotics have a wide antimicrobic spectra and in vitro they are less effective than penicillin against grampositive cocci but are much more effective in vivo studies. Both these antibiotics are amphoteric compounds and their salts are generally referred to as aurecomycin and terramycin respectively. Their structures are very similar. Both contain a napthacene nucleus and all but two of the groups are alike in two antibiotics.



Aureomycin



Terramycin

In effect, aureomycin has a hydroxyle instead of chlorine but oddly enough, the two occupy different places in the napthacene skeleton. The basic structure common to both aureomycin and terramycin is called tetracycline and thus Aureomycin is named chlorotetracycline and Terramycin is designated as oxytetracycline.

Aureomycin is a weak base that contains both nitrogen and nonionic chlorine. The free base has a melting point of 168-169°C and a solubility in water of 0.5-0.6 mg/ml. This is much more soluble in dilute alkali or acid. It forms a crystalline hydrochloride containing one equivalent of HCl per mole of base. The hydrochloride of aureomycin is a bitter, odourless, yellow powder, soluble to the extent of about 1% in normal saline or in normal distilled water and pH of such solutions is of the order of 2.5-2.9. For intravenous application now seldom applied, saline or glucose solutions containing aureomycin salts are buffered by the addition of Na-glycinate.

Aureomycin hydrochloride is somewhat more soluble in methyle cellulose aqueous solutions which have been used for local applications of aureomycin to prevent scarring in varicella (chicken pox). When the solution dries, a protective antibiotic-impregnated film forms which tends to prevent formation of fresh vesicles and to accelerate the disappearance of those already present.

Aureomycin is now commercially produced by Lederle Laboratories, Inc., a subdivision of American Cyanamide Company. Aureomycin is the trade mark name and chlorotetracyclin is the generic name.

Terramycin is an important commercial antibiotic manufactured by Charles Pfizer and Co., Inc. It is produced by a new actinomycetes, streptomyces rimosus, so named because of the cracked appearance of the colonies on agar plates. It was discovered in the course of an extensive screening programme which in many years of testing covered 100,000 samples from all parts of the earth.

2. **Industrial Aspects**

The fundamental step in the industrial production of nearly all antibiotics is a biosynthesis performed by an appropriate strain of microorganisms cultured in a suitable nutrient medium, generally in tanks or fermenters varying in size from several hundred to 20,000 gallons capacity. The organisms are selected carefully and submerged fermentation technique makes it possible to provide throughout the fermentation cycle, the optimal conditions for rapid production of the desired antibiotic. The microorganisms used industrially for production of antibiotics are aerobes, *i.e.*, they must have access to atmospheric oxygen in order to carry on the normal respiratory activities from which is derived the energy required for their growth and biochemical reactions involved in the maintenance of all their metabolic activities. First of all, microorganisms are eliminated by filtration and antibiotic is recovered by one or more physico-chemical mothods. The crystalline or the amorphous final product is sterilized by some appropriate method and freed from water by lyophilization. Later on it is tested for potency, sterility, toxicity, clarity, absence of pyrogenes and moisture content before entering commerce for medicinal use.

For the production of aureomycin, S. aureofaciens is employed by the two methods given below:

(1) Flask Fermentation.
(2) Deep Tank Fermentation.

(1) *Flask Fermentation*—

100 ml of medium containing

1-3%	Sucrose
1-2%	Corn steep liquor
0.5%	$(NH_4)_2HPO_4$
1.5%	KH_2PO_4
0.2%	$MgSO_47H_2O$
Traces of	Mn, Ca, Zn

was taken and pH of the medium was adjusted to 6.2, and placed in a 500 ml Erlenmeyer flask, sterilized, inoculated and then shaken continuously at 28° for 24-36 hours. From 500 to 2000 aureomycin units are produced. Yield of aureomycin on a weight basis is in the order of 500 to 750 mgs per litre.

(2) *Deep Tan Fermentation*—

The medium here is somewhat more dilute as compared to one given above, contains 0.1% $CaCO_3$ and during fermentation, medium is kept at 26°C to 28°C and aerated at the rate of 0.5 to 1.5 litres of air per litre of medium for 24-48 hours. The pH of the medium may decrease to 4.5 during fermentation.

The aureomycin is precipitated from the broth with lime at pH 8.8, it is then extracted from the filter cake with sulphuric acid at pH 1.35. The filtrate is evaporated in vacuum at 30°C to about one fourth its volume, a small quantity of butanol is added and the solution is nearly saturated with sodium chloride. On standing overnight at 2-5°C, the aureomycin crystallizes as the hydrochloride of about 97% purity.

A typical medium suitable for the production of terramycin contains about 3% soyabean meal, 0.5% cornstarch, 0.1% NZ-Amine B, 0.3% sodium nitrate and 0.5% calcium carbonate. It is adjusted to pH 7.0 and after sterilization is seeded with a 2.5% by volume of the innoculum of the organism. The organism employed is "S. rimosus". Incubation with aeration and agitation is carried out at 24°C to 30°C for about 48 hours and then the broth is processed. Yields are expressed as Coli Dilution Units (CDU) and range from 280 (CDU) per ml in 400 gallon tanks to 2,560 in litre gallon glass fermenters. In shaken flasks, 640 (CDU) per ml are reported. Terramycin is isolated from the broth by filtering off the mycelium, absorbing on Norite at pH 7.0, eluting it with water saturated with butanol at pH 1.5, transferring first to butanol at pH 9.0 and then back to acidified water. On neutralizing to pH 7.5, a precipitate of crude terramycin is formed. Crystalline terramycin can be obtained by further purification and final crystallization from water or methanol as the free base, the hydrochloride or the sodium salt.

3. **Applied Aspects**

Due to the availability of aureomycin and terramycin it has now become possible to treat cases chemotherapeutically which would otherwise call for surgical intervention. Both of these antibiotics when used separately in doses of 1 gram daily for 20

days, have yielded better than 90% cures in treatment of amebiasis. Patients suffering from "brucellosis" return to their normal temperatures in 3-5 days, and liver, kidney, spleen and blood cultures may become normal in about a week's time. Each of these antibiotics inhibits the multiplication of Rickettasias and pneumonias of bacterial origin as well as being useful in tropical medication and ocular infections. However, it has been observed that frequent administration of either of these antibiotics is followed by gastric upset, vomiting, diarrhea, etc. These symptoms are associated with the predominance of yeasts and deficiency of the vitamins of the B Complex, and this can be alleviated by concomitant administration of the B-vitamins.

4. Role in Mixed Antibiotic Therapy

Owing to the limitations of each antibiotic, the trend is now towards employing a combination of two or more antibiotics for controlling various microbial species. This practice, often referred to as "Mixed Therapy", offers advantage in controlling efficiently diseases which involve mixed infections. By suitably choosing a pair of antibiotics, the chances of survival of the mixed bacterial infections are reduced considerably. Some typical examples of the use of mixed antibiotics in curing various infections are cited below:

Infectious Agent or Clinical Symptom	Combination Reported to be Effective
1. Amebiasis	Terraymycin + Pumagillin
2. Brucellosis	Aureomycin + Streptomycin.
3. Brucellosis	Terramycin + Chloramphenicol
4. Lung Abscess	Penicillin + Terramycin.
5. Meningitis	Terramycin + Sulphonamide.
6. Pyelonephritis	Aureomycin + Streptomycin.
7. Salmonella typhosa	Terramycin + Chloramphenicol
8. Staphylococcus aureus	Terramycin + Streptomycin.

The most useful effect to be sought in mixed therapy is, of course, synergism or an effect greater than that to be expected from simple summation of the independent actions of the two drugs. When used in pair, the broad spectrum antibiotics (aureomycin and terramycin) differ considerably from narrow spectrum antibiotics (penicillin, streptomycin, bactracin, neomycin) both with regard to their useful range of antibacterial activity as well as their net biologic effects. Members of the first group act additively while those of the second group act synergistically. Broad spectrum antibiotic tends to antagonize the effect of narrow spectrum antibiotics while the narrow spectrum drugs do not seem to interfere with the action of the broad spectrum antibiotics and even may synergize the action of the latter against organisms that are resistant to but can be inhibited by a large dose of a particular narrow spectrum drug.

5. Mechanism of Actions

Aureomycin and terramycin embody a group $(-\underset{|}{C}-\underset{|}{N}H)$ structure and thus might interfere with reactions concerned in synthesis and/or utilization of proteins.

Aureomycin is found to interfere with the essential steps in respiratory mechanism. In case of Escherichia coli, Pseudomonas aeruginosa and Proteus vulgaris, it blocks aerobic utilization of pyruvic acid and with respect to action on these gramnegative bacteria, aureomycin interferes with the citric cycle by specifically blocking the use of pyruvic acid as a substrate in aerobic respiration. This effect occurs irrespective of the presence of citric acid or of any other di- or tricarboxylic acids.

The effectiveness of this antibiotic against various pathogenic viruses is due to inhibiting the phosphorylation processes in host tissues. Owing to similarity in chemical composition, they become intimately associated with the phosphorylation processes of the cells and deprive them of an adequate supply of phosphorylated compounds thus preventing their multiplication. Terramycin blocks the utilization of vileo nucleic reserves in various microorganisms.

6. Uses and Other Aspects

(1) *Use in Dental and Oral Surgery*

Aureomycin and terramycin are effective against diseases like chronic diffuse osteomyelitis, actinomycosis, recurrent oral ulcerations and cases of Vincent's Stomatitis. Cones containing aureomycin are used for treatments of acute abscesses, isolated periodontal pockets and chronic periodontal abscesses.

(2) *Use in Agriculture*

Animal diseases such as brucellosis, mastitis and actinomycosis are very well controlled by these drugs. Poultry and swine show marked gain in growth when fed on rations supplemented with the above antibiotics. Calves up to the age of three months gain in weight rapidly if fed diets containing small amounts of aureomycin. Lambs do not show any marked gain in weight and with doses of aureomycin above 14 milligrams per lamb per day, they may decrease the weight gain and feed efficiency. These antibiotics accelerate the growth of young animals by affecting physiologic processes involving water uptake, utilization of protein and metabolism of fat.

Both of these antibiotics retard the spoliage of minced meat, fish and crab. They have been found to be best in controlling microbial spoliage in fish, meat and poultry.

7. Summary

Aureomycin and terramycin are amphoteric compounds and are synthesized by the species streptomyces. Both contain napthacene nucleus and basic structure common to both these antibiotics is named as chlorotetracycline (aureomycin) and oxytetracycline (terramycin). Aureomycin is now produced by Lederle Laboratories, Inc., while terramycin is being manufactured by Charles Pfizer and Company, Inc.

Aureomycin is produced by streptomyces aureofaciens and terramycin is produced by streptomyces rimosas. Aureomycin is produced both by flask and deep tank fermentations, while terramycin is produced by shaken flask fermentation. Both of these antibiotics are useful as chemotherapeutic agents and are useful in the treatment of Brucellosus and Amebiasis. They prevent Ricketasias, pneumonias of bacterial origin, and ocular infections.

Owing to the limitations of each antibiotic, mixed therapy is now being advocated. Various pairs of antibiotics for various infections have been described.

It is now believed that the effectiveness of these antibiotics is due to inhibiting the phosphorylation processes in host tissues.

Both of the above antibiotics are useful in dental and oral surgery, in agriculture, and food preservation.

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PACKAGING

BY

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1. Definition

Packaging may be defined as a unit operation and a material handling device which facilitates the movements of food products from the time they are produced to the time they are consumed. In other words, it is a technique for promoting sales and advertising of various products to an appreciable extent.

The word "package" originally meant a "bale" or "bundle" of goods and in the food area, it is normally used to denote a basic unit in which a food article is initially packed and delivered to the ultimate purchaser or consumer over a retail counter. Consequently it is now usually defined as any receptacle or carton in which a food commodity is packed as well as any wrappings in which it is enclosed and put up for sale.

According to the verdict of the United States Supreme Court, a "package" may be defined as the "immediate container of the article which is intended for consumption by the public". In connection with another decision, the word "package" was declared to specify the "package made up by the manufacturer for sale to the ultimate consumer which goes into the possession of the person who will use the article of food".

2. Functions of Packaging

Since food products are liable to undergo much deterioration during movement, it is desirable to incorporate many qualities in a package so that it could adequately preserve foods during transit as far as possible. A package must, therefore, be made up of such materials as would enable it to perform a variety of functions which are normally expected from it. Obviously the question would arise as to what are those functions which are so important:

Firstly, a package must protect the food product. Sometimes a food product might have to travel around the globe or even into outer space—which now seems a possibility due to the advent of Spacemanship—and this may entail journeys of days, months and even years. Hence, a package must protect the product from thermal changes, from humidity variations and from the hazard of rough handling.

Secondly, a package must be in a form convenient to handle in the production line, wholesale and retail channels of distribution and the consumer's hut.

Thirdly, a package should be economical for a good producer because profits in the food field are very marginal and even differences of fractional pennies in cost are sufficient to attract or repel consumer favour and as such, packaging costs are looked upon with an eagle eye.

Fourthly, a package should be such as to stimulate maximum appeal in the customer for the packed product. Also, package surface should lend itself remarkably to certain characteristic features which are important to the consumer who has become accustomed to quality of certain brands. It is equally important to the producer who is at considerable pains to maintain consumer favour by keeping his quality standards.

Lastly, a package should provide a barrier against the loss of volatile native flavours of foods or the pick up of foreign flavours by the foods which might otherwise lower their quality considerably.

In addition, a package

(1) should not allow the passage of liquids, fats and oils etc.,

(2) should be resistant to acids and other corrosive food components.

(3) should have good resistance to mechanical damage and

(4) should show tight sealing under normal conditions of handling.

3. Design of Packages

Much of the success in promoting increased sales depends upon the efficiency in the design of packages. A design with harmonious colours allures consumer's eyes, even though there may be no conscious appreciation of such designs. With the advent of mass production, sales managers are becoming much more concerned with mass sales. There is going to be a change in the tastes of the people and hence a new kind of package designer is needed who could do a great deal more than just paint pretty colours on cardboard boxes. A successful package designer should not only be acquainted with business but he should know the people and be well versed in the vagaries of fashion affecting styles.

In order to evolve a good package design, a package planner should take the following points into consideration:

1. Physical form of the product.
2. Type of protection required.
3. Appropriate packaging material, especially as far as its structural qualities and availability are concerned.
4. Equipment problems such as efficiency of packaging equipment and its structure, etc.
5. Package material should be convenient for storage and handling on production lines and on packing, shipping, wholesaler or retailer platforms as well as consumer's house.
6. Cost of the package and merchandising considerations.

It is imperative that a designer must think over various aspects mentioned above before he actually puts his pencil to paper in making a plan. Also, a designer is supposed to have a working knowledge of packaging operations like package filling, handling and merchandising. In case these prerequisites are fulfilled, a designer shall normally prepare a model or dummy structure of the package he thinks shall be useful and then conducts tests on its adaptability to operations in collaboration with the production, sales, promotion and advertising departments. Thus it can readily be seen that a package designer should combine in himself all the desirable qualities of an artist, an engineer and a sales specialist. If it is so, there can be little doubt as to the ultimate success of his designs in actual practice. In spite of these qualities, it shall be appropriate if a package design is actually scored with respect to attracting public, memorizing value and finally capacity to invite purchases.

Nowadays, the trend is that many businessmen have adopted a policy of constant improvement in packaging both as to design and structure from time to time depending upon the changing tastes of the public, and most often consumers welcome such change as evidence of a desire to please.

4. Kinds of Packages

There are several types of package containers now available in the market, each one of which may either be suitable for most foods or may be a special container for particular types of foods. Broadly speaking, all packages may conveniently be classified under the following headings:

(1) Paper containers.

(2) Metal containers.

(3) Glass containers.

It is worthwhile to give more details about the kinds of packages listed above.

(1) *Paper Containers*—

Paper is a very versatile material which lends itself to many shapes, forms and purposes and is thus most often preferred for making packages of various kinds. Packages normally made may be classed as follows:

(*a*) *Bags and Envelopes*—

Bags may be made of Kraft paper, glassine, vegetable parchment, waxed paper or cellophane. Sometimes special types of bags or envelopes are made with sufficient moisture proofness to se rve for dehydrated foods. With the introduction of new bag-

making machinery, it has now become possible to buy bags at a price as low as 25-35 cents per 1000.

The packaging of solid food materials such as sugar, salt, flour and various powders is, nowadays, practised in paper bags owing to their great flexibility. The bags may be flat, square, automatic, self-opening and satchel-bottom type. Large quantities of film satchel-bottom bags are in current use for dried and fresh vegetables, noodles, candies and many other food products in self-service shops.

(*b*) *Wrappings*—

This may also be made up of a variety of materials such as glassine, waxed paper, vegetable parchment and cellophane. A wrap is chiefly used for bakery products, cheese, butter and candy bars; and when used in conjunction with cartons and paper boxes, it may also be employed as a protective membrane for cereal and similar products. One of the most important developments in the packaging field is the wrapping of fruits and vegetables which has greatly extended the storage life of these foods.

(*c*) *Set up Paper Boxes*—

This is made out of non-binding boxboard and usually has an outside wrap of decorative paper or bears a lithographed design. This type of package is widely used for packing cosmetics, confectionery and sometimes for fancy preserved fruits or specially bakery products.

(*d*) *Folding Boxes and Cartons*—

Folding boxes and cartons are now being increasingly employed due to their ease in handling, economy in initial cost and their light weight. They are made in a variety of sizes and shapes from materials such as chipboard, paperboard or heavy paper coated boards which provide an improved barrier to moisture vapour penetration. Out of all boxes, folding cartons have played an important role in modern food merchandising owing to its relatively high cost, ease in assembling, filling and multiprinting operations.

Butter, lard, oleomargarine and similar products which must be refrigerated throughout distribution make extensive use of this type of package.

(*e*) *Liquid-tight Paper Containers*—

These containers are made out of high quality bleached sulphite paper coated with wax with a view to insure moisture retention. Owing to shortage of metals, three types of containers have assumed greater importance and are widely used for cheese, butter, ice cream, pickles and milk.

This is especially adapted for use with semi-bulk merchandising and for products of a perishable nature.

(*f*) *Fibre Cans*—

They are prepared by winding spirally or convolutely, the ribbons of fibre. Any diameter, shape, thickness or height can thus be made in either of the two cases mentioned above. Recently they have been found to be of much use for packing syrups, spices, cereals and seeds.

(*g*) *Coatings and Laminations*—

Through research it has been found possible to use resins, lacquers and plastic coatings which may be applied to paper or fabrics to impart qualities of structural strength and resistance to moisture, acids and corrosion.

Quite a large number of laminations are now appearing which may vary from glassine laminated to cellulose sheeting and from Kraft laminated to metal foil.

(2) *Metal Containers*—

Metal containers are commonly made out of steel, aluminum, lead and tin. Tin cans are now widely in use. Tin

plate is prepared by coating sheet steel with tin. 1.5 pounds are normally used to coat about 80 pounds of sheet steel. This coating prevents rust and possible chemical action after the can has been filled and sealed. Also, tin assists in the soldering operation. Sometimes lacquer or other coating may be used, in addition to tin.

A metal can is principally used in the packaging of fruits, vegetables and beverages which are going to be heat processed, pasteurized or sterilized after the cans are sealed. The cans may be flat, oblong, short, or tall. Lead, tin and aluminum are extensively used in sheets of metal foils or extruded in the form of collapsible tubes. Foils are particularly useful because of their ability to resist light and heat as well as retain moisture. They can be used in the form of wrappings, bags or envelopes.

(3) *Glass Containers—*

Glass containers have the advantage of imparting visibility. Blue glass is common for drugs and medicines while amber and green glass are used for pickles, preserves, condiments and soft drinks. These colours permit some visibility of content, impart a certain attractiveness of appearance and prevent the fading of product colour. Usually catsup and pickles appear in narrow necked bottles while wide mouthed jars are used for coffee and canned foods.

5. Materials of Packaging

The principal materials employed for packaging are the finished products of other industries, the basic elements for which come from all over the world. Paper and paperboard may be made from pulpwood obtained from Norway or Africa or Canada and its coating may be made from casein and chalk obtainable from South America. Pigments for inks and lacquers can be supplied by many other countries and tin may be made available from Singapore. Rubber which may be employed for gaskets of glass jars and sealing compounds for tin cans comes from Malaya and certain Latin American countries. Generally it is opined that raw materials for the packaging industries exist in plenty. Similar is the case with plastics.

Many innovations of packaging materials are constantly being developed especially in case of plastic films, laminated and coated papers. Recently a modified vinyl film had come in common use in the manufacture of oleomargarine package which is useful for the preservation of such products as liver sausage, meat loaves, cured cheddar cheese and pickles in brine. Also, polyethylene, Sarans and modified vinylidine films have become available.

6. Packaging Operations

Packaging operations may be defined as a series of steps necessary to get the product into the container quickly, economically and in deliverable condition. These operations are, so many times, the deciding factors in the acceptance or rejection of a package suggestion particularly as to its form or material. It is expected that a package designer shall always take into consideration the equipment on which packaging operations are performed. Success in proper storage and handling of packaging materials prior to its actual use cannot only avoid the losses of the material itself but of equal importance are the efficient use of time and money spent in this connection. With a view to avoid these changes it is preferable to have a storage room convenient to the packaging line and storage conditions should be safeguarded to avoid dust, rough handling, dampness and temperature fluctuations.

Handling operations are mainly concerned with receipt of raw materials, raw material storage, transfer of raw material to the production line, movement of in process items from operation to operation during the production process, removal of finished items from the production line to the finished goods storage and finally shipment of customer orders. Equipment involved includes many types of trucks, conveyors and hoists and it has resulted in the efficient utilization of such practices as palletizing and unitizing, etc.

Important points to be considered in the handling of dry food products include the fill of the container, selection of a right

type of machinery in keeping with the consistency and the character of various food products. Machines employed in food packaging may be classified as follows:

(a) *Fully automatic carton loading machines*—

These machines perform all the various operations of opening, loading and closing a folding carton. They feed the collapsed folding carton from a magazine, open it, insert one or more items and close the ends of the carton.

(b) *Semiautomatic carton loading machines*—

They feed the collapsed folding cartons from the magazine, open it and carry it past loading stations where operators place the load in the carton by hand. The flaps are then closed automatically. Some machines carry the carton horizontally to be loaded from a table or synchronized conveyors, others carry the carton upright to let the operator insert the load vertically or end fill it.

(c) *Carton opening machines*—

They feed the folding carton from a magazine, open or set it up, close one and discharge it for subsequent manual loading and closing of the other end.

(d) *Carton closing machines*—

They receive the folding carton after it has been loaded and then tuck or glue one or both ends.

In the case of cake flours or cooked cereals, "tight wrapping" is sometimes performed. In this case the outer wrap is fully immersed in water so that it will cling and shrink. A product of this kind may contain shortening and so must be protected against high temperature, sifting and infestation.

Bag filling machines may vary from a single head semiautomatic type to the multihead fully mechanized type. The operations performed by the latter may include feeding the bags into the machine, opening them up ready for filling, filling and weighing the contents, settling and sealing them and ultimately delivering them ready to be packed in containers.

Machinery for Hot Processed Products—

The raw material in this case is freed from foreign substances, carefully inspected and packing operations commence with the filling of containers, exhausting and sealing before subsequent thermal processing including final cooling. Packaging is then continued with labelling, warehousing and packing operations. The product in this case is filled either in case or glass containers and the two principal types of cans used are "Packers cans" and "general line cans".

Packaging Machines for Liquid Foods—

The filling of containers for liquid and semiliquid products is done by machines having 30-40 filling spouts. The single spout filler is usually semiautomatic and the measuring is done by inspection to fill to a certain level. The elaborate machines have a device of filling the containers to a uniform weight. Automatic cut offs are employed to prevent waste of the product and provisions are also made in a sanitary way to return the overflow to the main tank, Closures may also be employed by machinery which may vary from hand operated screw-caping machines to multiple chuck fully automatic machines.

Other Packaging Machines—

Labelling of containers is also done by machinery which may be single head for putting tiny spot labels on small bottles or automatic straight line labeller, capable of applying front and back labels to a dozen of more packages at a time.

7. Packaging of Variety Foods

Various types of packages are employed for various kinds of foods or even similar products are sometimes packaged in different containers depending upon methods of their distribution and the merchandizing philosophies of the manufacturers. It is, therefore, desirable to present in a few lines some of the trends in packaging various kinds of foods of the modern world:

(a) *Cereals*—

Puffed cereals are packed in printed cellophane bags or in some cases in duplex bags. Cold cereals are packed in

folding cartons which due to their high degree of moisture proofness afford protection to the food product. Hot cereals are packed in heavy gauge folding cartons and sometimes in all fibre cans due principally to less sensitivity to moisture changes.

Macaroni products are packed in a particular style of folding carton which is relatively long as compared with its cross section, and is a lock end type carton with a tucked top. It is moisture proof, gives physical protection to the product, is low in cost and adaptable to semi-automatic packing operations. Bread flours require a strong and attractive bag which is resistant to sifting and easy infestation. High strength Kraft paper is usually employed for this. Bread is packaged in heat sealed wrappers of printed waxed paper, though a special grade of moisture proof cellophane is popular. Cake flours are packed in folding cartons having an inner lining of laminated glassine owing to the hygroscopic nature of ingredients.

Crackers are packaged in Peters' type cartons using a liner of plain or waxed glassine and a loose printed paper overwrap.

(*b*) *Dried Fruits and Vegetables*—

Tin cans, either friction top or hermetically sealed, are proof against insects and ideal containers for fruits and vegetables shipped to or through the tropics or to warm humid districts. Owing to high cost, they have not found much popularity and therefore dried products are still packed in paper cartons or boxes.

(*c*) *Frozen Fruits and Vegetables*—

Paraffined cardboard cups and tubes are in common use for frozen pack foods and have proved fairly satisfactory. For institutional trade, large cellophane lined cartons are in use. Acid foods are packed in hermetic containers such as tin cans and glass bottles.

(*d*) *Miscellaneous*—

The cellulose acetate foil combination is chiefly used for packaging hygroscopic foods like dried yeast, soluble coffee, dried milk and dehydrated soups.

8. Quality Evaluation

Quality evaluation is a very efficient tool for appraising the probable performance of packages under factory conditions. Recent technical research has enabled scientists to simulate every conceivable stress and conditions to which packages and their component materials are known to be subjected.

Such tests provide a key for selecting appropriate designs, maintaining good quality and preventing useless expenditures. Commonly used packaging materials are wood and paperboard. They are sensitive to atmospheric conditions, and changes in moisture content greatly influence fundamental strength properties such as compressive resistance, bursting strength and nail shearing resistance. Tests usually employed include revolving drum test, bursting test, compression test, puncture test, drop test, tensile tests, tear tests, moisture proofness test and acoreline tear test. Details of these tests are available in many standard books and as such no effort shall be made in outlining them in this presentation.

Generally speaking, foods are packed in their prime condition and as soon as they are packed, they start to deteriorate. A package is primarily employed to check the rate of deterioration and therefore much emphasis should be placed on the fact that the package material, in itself, is sound qualitatively. Hence the need for quality control is paramount.

9. Summary

Packaging is a means of conveying food products from the producer to the consumer in a very satisfactory state. In order to fulfil this objective, a package must be convenient to handle, protective, economical and appealing to the public. Efficiency in incorporating these desired qualities depends upon the efficiency of the package designer. A package planner should also take into view the various packaging operations through which a package is supposed

to pass so that no difficulty is encountered in actual practice.

Various types of packages employed for packaging of foods include paper, metal and glass containers, each one of which is remarkably suitable for various foods. Raw materials employe d for the manufacture of these containers are usually products of other industries whose resources are imagined to be plentiful.

Handling operations normally involved include receipt and transfer of raw material to production line, from then on to the processing line and finally shipping of individual orders. Machines commonly employed included fully automatic and semiautomatic carton loading machines and carton opening and closing machines. Operations for different foods differ slightly from each other, details of which have been given. Also, the types of packages employed in packing different foods are quite dissimilar and their points of interest, if any, have been presented. However, it must be emphasized that the packages are primarily responsible for maintaining quality of foods during transport and as such no time should be lost in preassessing the qualities of various packaging materials themselves.

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KARYOKINESIS IN FLOWER BUDS OF TOMATO
(Lycopersicon Esculentum)

BY

MUHAMMAD YAQUB, M.Sc. Agri. (Pb.); M.Sc. (Arizona); Dip. (Wisconsin).

Two processes govern and insure the continuation of species from one generation to the next. In broader sense, these are the union of cells and the division of the cells. The latter process is the characteristic of all cellular organisms, while the fo mer is found in those organisms that produce sexual cells or gametes.

The union of cells, or syngamy, is a portion of the process or sexual reproduction. It involves the union of gametes which, depending on the species, may be morphologically similar or dissimilar. In the higher plants and animals, the actual fusion may be restricted to the nuclear portions of the cell, the cytoplasmic portions of the male cell being largely discarded in the process. Associated with syngamy is a modified division called meiosis, which in a genetic sense, is its equal and oppos te, for while syngamy increases the number of chromosomes through the fusion of nuclei, meiosis by a special type of division reduces this number.

A detailed knowledge of these processes is a necessary pre-requisite to an understanding of heredity. This paper deals with the study of karyotype analysis of tomato flower buds for the meiotic studies.

REVIEW OF LITERATURE

Very important information for understanding the transmission mechanism of heredity came from studies of the behaviour of chromosomes during the formation of gametes in animals and of spores in plants. These studies were initiated by Boveri (1887) and developed by Montgomery (1901), Janssens (1909), Darlington (1931), and many others. The behaviour of the chromosomes during these processes is extremely variable in different organisms, and there is still much to be learned about it. It is important, however, to see beyond these variations the significant common features that occur in most organisms in which sexual reproduction is observed (Sinnott, 1958).

Rhoades (1950) working on maize has stated that in the leptonema stage the chromosomes are long and slender and numerous small and distinct chromomeres can be seen. Heterochromatic regions known as knobs are present. At zygonema pairing of like chromosomes takes place. The chromatin threads form a tight knot next to the nucleolus. Some pairing occurs b fore this so-called synizetic knot is formed and an occasional free arm protrudes which may be seen to be double. He further states that at pachynema the individual maize chromosomes may be distinguished from each other by their relative lengths, deep-staining knobs, and position of the centromeres. There is a contractions in length due presumably to the ceiling of the chromonemata. According to him "Diplonema is characterized by a two-by-two opening out of the paired homologues to form loops and nodes. Most of the nodes represent chiasmata, *i.e.*, an exchange of partners." The four chromatids can be differentiated clearly in some cases.

MATERIAL AND METHODS

The tomatoes plants were grown in a green house of the Horticultural Department, University of Arizona, Tucson, U.S.A Navashin fluid or solution was used for killing and fixing the material. Acetocarmine was prepared in the Botany Laboratory under the guidance of Dr. Harris. No iron acetate was added to this staining material

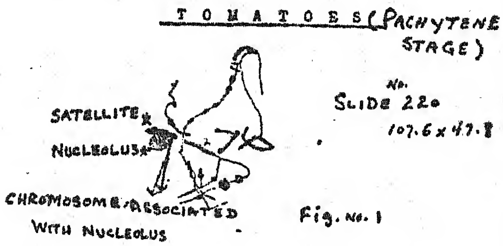
because too much iron precipitates the carmine. These studies were made on a phase microscape of the Botany Department.

RESULTS AND DISCUSSION

Studies on the meiotic behaviour of the chromosomes were conducted on Tomatoes. The diaknesis and pachytene stages were observed. A lot of difficulties were experienced to find out the desired buds for these studies. It was then considered that time for collecting the material may be contributing a lot to cell divisions. A study of these factors revealed the fact that the best time for collecting the flowers under those conditions was found to be 12.30 p.m. As far as the stages of development of the flowers were concerned, the one week old buds were found to be quite suitable for the studies.

The pachytena stage, as seen under the microscope, is given in Fig. 1. It was difficult to count the exact number of chromosomes since the entire length of any chromosome was not traceable. Rhoades (1950) has also expressed similar views about the counting of number of chromosomes at leptotene and pachytene stages.

The bivalent stage which is illustrat d in Fig. 2 presents a clear picture of the number of chromosomes. The haploid number of chromosomes will be noticed as 12. The chiasmata in certain cases, are quite clear. In Fig. 2 ('A') the chromosome number 2 seems to possess the nucelolus organiser. The pairing is quite normal. Similar indications were also evident in the pachytene stage where chromosomes number 2 appeared to have been associated with the nucleolus. This nucleolus organiser is setallitised by a secondary constriction as shown in the pachytene stage. The entire length of chromosomes was not traceable, hence it is rather difficult to count the exact number of the chromosomes. Chromosomes No. 2 seems to have been associated with the nucleolus. This nucleolus organiser is setallitised by a secondary constriction as shown in the diagram.



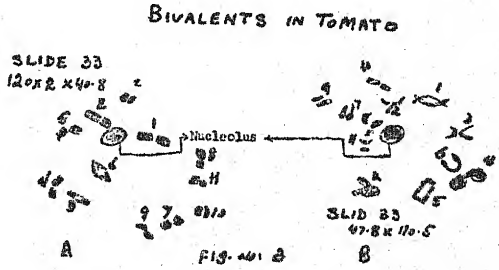


Fig. No. 2. Bivalents in the tomato. The haploid number can be counted at twelve. We can observe the terminalization. In Fig. 'A' the chromosomes No. 2 seems to possess the nucleolus organiser. The pairing is quite normal.

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CURING AND PROCESSING OF TURMERIC (Haldi) IN WEST PAKISTAN

BY

MUHAMMAD YAQUB, M.Sc., Agri. (Pb.); M.Sc. Arizona Dip. (Wisconsin)*

Turmeric (Haldi) is one of the most important species which is very commonly used in our daily life and is in use since time immemorial. It is considered to possess an antibiotic reaction in the body. Prior to partition of the Indo-Pak sub-continent no turmeric was grown on commercial scale in the area now constituting as West Pakistan. Even after partition till now, we have been depending on India for this important commodity, and turmeric worth about three crores of rupees had been imported annually from India. After a careful research we have come out successful in raising this crop economicaly under our conditions.

Since it is a newly introduced crop, some of the details regarding its curing and processing are yet to be worked out. This commodity cannot be kept in stores for longer periods as fresh. If the freshly harvested rhizomes are stored they give out shoots in the month of June or July, thus deteriorating the quality of the produce. Hence boiling and drying of the rhizomes becomes essential. Since a large number of enquiries are received for its processing and curing, it is considered imperative to publish a bulletin on this issue for the general information and interests of the growers. The freshly harvested rhizomes are cleaned and washed in water. After the soil is completely removed these are boild or subjected to steam for about 20 minutes till the rhizomes become soft and yield to the slight pressure exerted between two fingers. The apparatus used for steam boiling consists of a drum, a container and a stand. The dimensions of these utensils will depend upon the quantity of the rhizomes to be boiled. As a general rule for boiling 2 maunds of fresh rhizomes we would require a drum about five feet long and two to two and a half feet in diameter Two bars are provided widthwise at a height of one foot from the base of the drum. These bars will serve the purpose of a stand. The container should have holes or meshes so as not to permit the rhizomes to get out of it. The rhizomes are put in the container and placed on the stand, (iron bars) beneath which is one foot deep water. Whole of this apparatus should be air-tight. Then apply heat till the water begins to boil and forms steam. The heat should be withdrawn after 20 minutes.

2. *Drying.*—After the rhizomes are boiled they are dried either in the sun or by artificial means such as dehydrators etc. The moisture or rain should not be allowed to touch the drying rhizomes otherwise they will lose their colour and lustre. Experiments have shown that drying the rhizomes on gunny bags placed on pacca floor they absorb moisture and lose colour. This should be avoided.

3. *Peeling and processing.*—Shrivelling of the rhizomes takes place after these are boiled, dried and develop grooves on their surface. This presents a bad look and cannot attract the consumers. For this purpose processing becomes essential. Peeling of the skin is done in a drum of iron sheet having projections inwards. The inner surface of this container can be compared to that of a hoofed or shaggy surface of the 'moolikash. This drum is fitted on two pillars and churned just like churning of milk. In order to ensure a regular speed of this drum certain pulleys can be fixed. This process should continue till the skin is peeled off completely. After the skin is removed these rhizomes may be placed in a drum of even or plane inner surface and worked for about ten minutes. The natural colour of the rhizomes will adhere to the upper surface of the rhizomes.

Note.—It has been found that dealers use the chrome dye to impart colour to the rhizomes. This is a poisonous matter and should never be used for this purpose particularly when we have come out successful in giving to it its natural colour.

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INTER-CROPPING THE FRUIT ORCHARDS

BY

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No doubt the income received by the growers from an orchard is more than ordinary crops under normal circumstances, yet the initial costs and capital for planting an orchard are very heavy. In the canal colonies a heavy expenditure of at least 300 to 400 rupees have to be incurred for planting an acre with oranges. In the early life of the orchard there are hardly any returns from the fruit trees. A programme of inter-cropping would greatly reduce the financial burden of the orchard growers. A great care is, however, needed in the selection of the right type of crops. Adequate distances have to be left from the rows of the trees and have to be proportionately increased according to the size of the trees every year, the crop should not be grown beyond the spread of the branches of the trees.

Crops to be grown

Where ample facilities of manuring, irrigation and marketing are available the ideal course would be to grow vegetables like potatoes, chillies, onions, radish, carrots, cauliflowers, peas, turmeric, etc. The second alternative would be to grow fodder crops like berseem, guara or other leguminous crop like gram, cow-peas, beans, pulses etc.

Liberal manuring, irrigation, hoeing etc. required for the successful cultivation of these crops would also benefit the trees.

Crops not to be grown

Tall crops like maize, Jowar, sugar-cane and Bajra should not be grown. They are very exhaustive and would deplete the soil of its fertility and will compete the orchard trees for nutrients. They will also shade the young trees and would interfere with their proper growth.

Income

It will not be out of place here to mention that the incomes realized from the orchard in the beginning will almost be equal to the land sown to ordinary crops not planted with fruit trees. Vegetables like peas, turnips, radish, crops like berseem and gram were sown in the early life of the Government Progeny Garden, Risalawala, Lyallpur and very handsome incomes were received.

Vegetables like potatoes specially variety Ultimus can yield 300 to 500 maunds per acre during Autumn and Spring seasons and can bring an income of Rs. 1000 to Rs. 2000 per acre. Turmeric will also do well on a small scale and can bring an income of Rs. 500 to Rs. 1000 per acre particularly the two-year crop.

In one of the experiments performed on intercropping in a Government orchard gram gave as high a yield as 20 maunds per acre. However, special arrangements have to be made for growing such a crop so that regular irrigation is ensured to the young trees in the basins when gram crop requires only scanty irrigations.

The ideal crop to be sown in the orchard is our common berseem, it is not very much adversely affected by shade and being leguminous replenishes the fertility of the soil. It will give 400-500 rupees per acre as income. If the grower is interested in making seed, he is advised to leave it after two cuttings and 6-8 maunds of seed can be expected per acre. At a very conservative estimate about Rs. 60 per maund this can yield an income of 350 to 500 rupees besides the two cuttings of fodder already taken. Even in the case of well established gardens bearing fruits for several years experience has shown that cultivation of berseem as an inter-crop not only gives a very handsome fodder crop but also enriches the soil and has been instrumental in increasing the vigour of the trees. The growers are, therefore, advised to practise judicious inter-cropping in the gardens.

NUTRITIONAL DEFICIENCIES AND FERTILIZATION PRACTICES IN CALIFORNIA WALNUT ORCHARDS

By
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Prior to 1930 there was no proven general need for fertilization in California walnut orchards. Tests had disclosed no nutritional deficiencies or had been inconclusive up to that time. However, during the period of 1932 to 1937 scattered trials with nitrogen in mature walnut orchards indicated definite shortage of this element in some areas. Later trials showed more widespread deficiency and by 1950 yearly applications of nitrogen had become the standard recommended practice for bearing orchards in all districts.

During the early 1930's, Dr. W. H. Chandler discovered that the trouble known as walnut "littleleaf" or "yellows" was actually caused by a deficiency of available zinc. He cured trees by various methods of zinc application. Zinc treatment rapidly became standard practice in all districts where the deficiency was found. Zinc is now the second most commonly deficient nutritional element in California walnut orchards.

During the past thirty years, seven other elements essential for plant growth in addition to nitrogen and zinc have been proven deficient in scattered walnut districts in the state and methods of treatment have been developed. Unquestionably, additional deficiencies and affected areas will be found and more efficient methods of application are constantly sought. The most recent nutritional deficiencies demonstrated have been phosphorus, in hillside orchards on volcanic soils in Lake County and magnesium in a Sierra Nevada mountain foothill orchard.

Of the sixteen nutritional elements so far proven essential for plant life, nine have been found separately limiting growth and production in at least one location in California's 160,000 acres of walnut orchards up to this time. Only one, nitrogen, is generally needed in regular yearly applications in all districts.

Leaf Analysis

Leaf analysis has been a useful tool in locating areas of deficiency of the various elements excepting iron. It has been helpful also in testing the efficiency of different sources, amounts and methods of application of the needed elements. Normal and deficiency ranges for eight elements have been tentatively established although there is some variation between districts and overlapping of the upper end of the deficiency range and the lower end of the usually adequate range. When leaf analysis lies in this overlapping zone, symptoms may or may not be present. Additional data are needed to determine more exact boundaries. Therefore, the leaf analysis table given herewith should not be considered as an infallible guide on which to base fertilization practice. Rather, it can be used best as an indicator in conjunction with examination of symptoms and results of local trial plots in determining a good nutritional treatment program. (*See* Table 1).

At present, yearly applications of nitrogen are the standard practice in mature walnut orchards in California. Applications of other elements vary from district to district, orchard to orchard, and year to year as the need for them becomes apparent.

Following is a brief discussion of each of the nutritional deficiencies, symptoms, and treatments so far found effective:

Nitrogen.—Nitrogen deficiency is found widespread in all districts in mature orchards. It is sometimes found in young non-bearing orchards in sandy and infertile soils.

TABLE 1

*Content of Nutrient Elements in Dry Matter of Leaves of Deficient and Normal Walnut Trees**

Element		Deficient Range Deficiency symptoms usually noticeable	Intermediate Range Deficiency symptoms may or may not be present	Normal Range Deficiency symptoms rarely present
Nitrogen	...	1.5 to 2.0 per cent	2.0 to 2.5 per cent	2.5 to 3.25 per cent
Zinc	...	4 to 15 ppm**	15 to 20 ppm	20 to 200 ppm
Boron	...	6 to 19 ppm	19 to 35 ppm	35 to 300 ppm***
Manganese	...	6 to 20 ppm	20 to 30 ppm	30 to 350 ppm
Potassium	...	0.16 to 0.9 per cent	0.9 to 1.2 per cent	1.2 to 3.0 per cent
Phosphorus	...	0.05 to 0.09 per cent	0.09 to 0.12 per cent	0.12 to 0.3 per cent
Copper	...	1 to 3 ppm	3 to 4 ppm	4 to 20 ppm
Magnesium	...	0.06 to 0.2 per cent	0.2 to 0.3 per cent	0.3 to 1.0 per cent

*The figures in this table are not absolute maximums or minimums; different growing districts and rootstocks often show variations in maximum and minimum ranges for both healthy or deficient trees. Therefore, nutritional treatments are best based on symptom observations and field tests in addition to leaf analyses. Data in this table are based on numerous analyses of tip leaflets gathered from late June to early September. A leaf sample normally consists of 20 tip leaflets taken at random from mature leaves growing near the base of current season spots or shoots.

**ppm=parts per million.

***300 to 400 ppm, leaves show slight tip and marginal burn; 400 to 1000 ppm, leaves show severe tip and marginal burn, with trees seriously injured.

Symptoms are not always easy to recognize. They include pale colour and smaller than normal size leaves, generally sparse foliage, abnormally short length growth and poor yields of small sized nuts. Average annual length growth should be six to twelve inches or more in mature trees of heavy bearing varieties such as Payne in hot interior districts. In cooler areas, an average length growth of four to eight inches is usually sufficient. Lighter bearing varieties such as Franquette may bear normally with average length growth one-quarter to one-half less than in Payne type varieties. Weak growth of mustard or other non-legumes is usually a reliable indication of a lower than desirable nitrogen level in the orchard.

Nitrogen is available to growers in many forms. Organic forms such as manures, bean straw, and grape pomace may be used where available at low cost. They are usually more expensive in California than inorganic forms. Heavy manure applications often cause or increase zinc deficiency especially in sandy soils. Inorganic sources of nitrogen are generally used, such as ammonium sulfate, ammonium nitrate, anhydrous ammonia (NH_3), and ammonia in water solution. The decision regarding which material to use is usually based on relative cost per pound of nitrogen and grower preference. Sulfate forms are desirable on soils with alkaline reaction and undesirable on acid soils. Sodium nitrate is

not desirable for most California valley soils because of the sodium content, increasing salinity.

Tests of different rates of application in bearing orchards have usually shown a high return for the first 100 pounds of actual nitrogen per acre per year. An additional 50 pounds has often paid some profit over cost.

Additional amounts above 150 pounds per acre have usually failed to produce a profit except possibly during the first several years of treatment of a nitrogen deficient orchard.

Best results are obtained when the nitrogen level is kept continuously at a relatively high level in the orchard. Under California conditions of low rainfall, there are little or no leaching losses excepting in very sandy soils. On medium to heavy soils, annual maintenance applications of dry materials are broadcast after harvest or ammonia applications made whenever convenient with a spring or summer irrigation. In orchards where the nitrogen level is low and in very sandy soils where leaching may cause losses, mid-winter or early spring applications are made to meet the heavy demand during the spring flush of growth and flowering period. In very sandy soils, one or more additional applications during the summer may be needed. Similarly, if the nitrogen level is low, a special fall application may be needed to stimulate growth of the cover crop.

Zinc.—Deficiency of zinc is also found in most of the walnut districts of California, but usually only part of the trees in an area or an orchard are affected. It is most common on sandy soils but is not limited to any soil type.

Symptoms are easily identified in severe cases, including very small yellow leaves, dieback and very small nuts, if any. In moderate cases, there is chlorosis, curling and yellowing of leaves most noticeable after early June. In slight cases, the only noticeable symptom may be yellowing between veins with increasing colour toward tips of leaflets.

The standard treatment is driving of zinc bearing metal pieces into trunk or limbs. For small trees or limbs up to two inches in diameter, zinc glazier points can be driven by the use of a glazier point driver. Ten small points per one inch circumference driven through the bark and into the sapwood, spaced about one inch apart, are recommended. For larger trunks (up to 10 inches in diameter) or limbs of large trees, galvanized, iron pieces usually about one inch by two inches, 22 or 24 gauge, are driven by hand. They are placed vertically, parallel with the grain, and must go through the bark and about one-qu rter inch into the sapwood. Five rings of such pieces, two inches apart horizontally with two inches between rings, and pieces not placed directly above one another, usually supply sufficient zinc for three to five years or more. Pieces can be driven at any time.

Soil treatments are sometimes effective, but have been variable in results. Five to ten pounds zinc sulfate per tree for young trees and 10 to 50 pounds for larger trees, placed in a circular trench about six inches deep and two to six feet out from the trunk have been effective in some orchards, especially in very sandy soils. Recently, it has been found that the addition of one-half as much sulfur as zinc sulfate has made the soil treatment much more effective in sandy soils.

Spray treatments have been relatively ineffective.

Iron.—Lime induced chlorosis or iron deficiency is probably the third most commonly found nutritional deficiency in California walnut orchards. The excess lime ties up iron so that trees cannot make normal amounts of chlorophyll.

The symptoms vary from mild paling of leaf colour between veins with a thin band of green along each large and small vein, to very pale yellowish and finally almost white leaves with final browning and death. Usually only one limb will be affected first. As the trouble progresses, there is progressive dieback from tips in affected branches, more branches are involved, and finally the whole tree is killed.

Walnuts on *Juglans hindsii* (Northern California Black Walnut) rootstock are

much more subject to the trouble than those on Paradox hybrid root and the hybrid is now being used for new plantings and for inarching in affected areas.

Soil sulfur 50 to 100 lbs. per tree in a circular trench has arrested deterioration of trees in test plots but works very slowly. The Chelate Geigy Chel 138, three to five pounds per tree in a trench has given good improvement for two years only at a material cost of $10.00 to $15.00 per tree. Iron orzan chelate injected in the soil at a cost of $4.00 per tree (20 lbs.) for material gave good improvement for four years in one test. Sprays have been ineffective. None of these chemical treatments tried thus far on old tree has been entirely satisfactory.

Boron.—Boron excess is much more common in California than boron deficiency. Sometimes excess and deficiency are found within short distances.

In severe cases of deficiency, limbs die back from the tip and there is only a weak, abnormal growth of small, distorted leaves. With more moderate cases, only pale colour and moderate distortion of leaves and poor crop may be noticeable.

Soil applications of borax broadcast evenly over the root zone in fall or early winter at the rate of 50 lbs. per acre (2 lbs. for a moderate size tree; 4 lbs. for a large tree) have given excellent results, effects of one treatment usually lasting two or three years. There is danger of damage from excessive applications, shown by burning of margins of leaves.

Manganese.—The symptoms of manganese deficiency are paling or yellowing of bands between veins and along margins of leaves with a wide band of normal green colour left along all the principal veins. There is browning of angular spots between veins and often extending to leaf margins. Early defoliation is noticeable in severe cases, especially in the upper part of the tree. The standard and very effective treatment is annual spraying with manganese sulfate solution, five pounds per 100 gallons, in the spring before leaves are quite mature (May or early June in California).

Potash.—Up to this time, only a few small areas have been found in California where potash is a limiting factor in walnut production. Upward rolling of leaflets and grayish colour on the exposed under sides are the usual symptoms with irregular burning along margins of leaves and sometimes in isolated spots also common. In one walnut area, there is a pale yellowish band along both sides of the midrib and the principal lateral leaf veins. Poor crops, weak growth and finally, dieback are also noticeable in severe cases.

Massive applications of potassium sulfate drilled into the root zone or placed in the bottom of trenches over the root zone have given great improvement noticeable during and after the second year following fall or winter treatment. Usually 50 lbs. per tree or 1300 lbs. per acre are used. Such a treatment may last for five or more years before retreatment is needed. Small annual surface treatments have been ineffective because of the fixing power of California soils. The chloride form of potash is undesirable for California valley soils because of danger of increasing salinity.

Phosphorus.—Deficiencies of phosphorus recently have been found in commercial walnut orchards on volcanic soils. Symptoms include bronzing, yellowing, irregular marginal burning of leaves and shedding of leaflets beginning with the basal pair following hot weather in July and August. Weak, slow growth may be the most noticeable symptom in young trees. Bearing trees yield poorly. Massive applications of triple superphosphate have given marked improvement lasting for five years or longer. Fall or winter applications in trenches six inches deep and two to ten feet out from the trunk, depending on tree size, have been effective. Amounts used have been 25 lbs. per tree for trees two to ten years old and 50 to 100 lbs. per tree for mature trees.

Copper.—Small areas of copper deficient trees, including one to several trees up to one acre, have been found widely scattered in coast range mountain, hillside and small valley orchards with a few cases in the central valleys. Some such locations have been identified as old American Indian mounds or camp sites. Dropping of tip leaves, yellowing and dying back of current season growing tips in late summer, with dark brown spots in the bark, are common

symptoms. Often progressive irregular burning of leaves can be found with distinct lines marking the margins of progressive advances of burned areas (zonation). Nut kernels are often completely shrivelled and shells have a pale, chalky appearance. Copper Bordeaux sprays made at the rate of ten pounds copper sulfate and ten pounds hydrated lime per 100 gallons and applied annually just after pollination is completed have been effective. Copper chelate sprays have also given some results. There is danger of copper injury to walnut trees if solutions are too strong or applications too frequent.

Magnesium.—Only a few cases of magnesium deficiency have been found in California walnuts. The principal symptom has been the development of a wide band of yellow colour around the margins of eaflets during late summer. The band extends about half way from margin to midrib at a point two thirds of the way from the base to the tip of the leaflet, includes the entire tip area and narrows toward the base of the leaflet. The yellow band gradually fades to brown and dies in early fall if the deficiency is severe. Growth rate in young trees is decreased sharply below normal.

Tentative recommendations for treatment include spray applications in May or early June with magnesium sulfate at the rate of five pounds per hundred gallons of water. Soil applications of magnesium sulfate in trenches probably will be effective in neutral or alkaline soils. Amounts of 5 to 20 pounds per tree are suggested by limited tests on small trees. Tests carried on with other deciduous species in other states indicate that Dolomitic limestone broadcast at the rate of one to three tons per acre should be effective in acid soils.

SCOPE OF FRUIT PRESERVATION INDUSTRY IN WEST PAKISTAN

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Different kinds of fruits suited to various climates in Pakistan are produced in large quantities. Good quality citrus fruits are grown in Multan, Lyallpur, Montgomery, Sargodha districts and some parts of former Sind Province of West Pakistan. Deciduous fruits like plums, apples, pears, apricots and peaches are mostly produced in north-west part of West Pakistan. The districts of Multan, Muzaffargarh and D. G. Khan are famous for choicest table as well as sucking mango varieties, dates and pomegranates. Guavas are grown nearly throughout West Pakistan. Former Baluchistan area produces good quality grapes. East Pakistan similarly produces a variety of fruits including pineapple, mangoes, citrus and papaya etc.

According to a 1958 report of the Co-operation and Marketing Adviser to the Government of Pakistan, Karachi on Marketing of fresh fruits the annual production of fresh fruits in Pakistan is 6,91,14,000 maunds. Fifty five per cent of this production is banana, while mango and citrus fruits are 34.5% and 7.0% respectively. Out of this nearly 10.0% to 20% of fresh fruit goes to waste due to the following factors:

(*i*) Poor cultural practices.

(*ii*) Inadequate picking techniques and picking of immature fruit.

(*iii*) Lack of knowledge regarding grading standards and packing methods.

(*iv*) Lack of uniform system of containers for packing fresh fruits.

(*v*) Poor transportation facilities from orchards to markets.

(*vi*) Improper handling methods at the garden sites as well as at the markets, and storage conditions at the fruit markets.

(*vii*) Inefficient working of fresh fruit assembling and distribution agencies.

To save losses due to some of the above mentioned factors, preservation of some of the fruits was undertaken during the pre-independence period. Extensive research work was carried out at the Horticulture Section of the Punjab Agricultural College and Research Institute, Lyallpur on the utilization of fresh fruits converting them into various products and standardisation of these products. The following products prepared from various fruits were standardised.

Squashes, marmalades (Orange), Orange peel candy, other fruit candies, fruit jams and jellies, morabba, chutney, canned and dehydrated fruits and vinegar.

At that time common man was totally unaware of their values nutritional or otherwise. In order to stress such a need a fruit and vegetable extension service was started in the former Punjab (undivided), under the Horticulture Section at this Institute. The object of this service was to popularise these products among all groups of people in the country. This object was accomplished by (1) holding short course (3-4 days) classes at civil and military training as well as educational institutions where the methods of preparation on home scale of different fruit products were demonstrated. In most of the cases some raw material was also supplied by the Horticulture Section to those institutions which did not have provision for such funds, (2) free distribution of leaflets giving the methods of preparation for all fruit products which were already standardised.

Composition of some Important Fruits per 100 *Grams, Edible Portion*

	Protein grams	Carbohydrate grams	Calcium mgm.	Phosphorus mgm.	Iron mgm.	Vitamin A. I.U.	Thiamin mgm	Ri oflavin mgm	Niacin mgm	Ascorbic mgm
Apples ...	0.3	14.9	6	10	0.3	90	0.04	0.03	0.2	5
Apricot ...	1.0	12.9	16	23	0.3	2790	0.03	0.05	0.8	7
Banana ...	1.2	23.0	8	28	0.6	430	0.04	0.05	0.7	10
Guava ...	1.0	17.2	16	33	0.9	200	0.04	0.04	1.0	300
Jujuba ...	1.2	27.6	29	37	0.7	400	0.02	0.04	0.9	69
Lemon ...	0.9	8.7	40	22	0.6	...	0.04	...	0.1	50
Mango ...	0.7	17.2	9	13	0.2	6350	0.06	0.06	0.9	41-150
Orange juice fresh ...	0.8	11.0	19	16	0.2	190	0.08	0.03	0.2	49
Orang juice canned (unsweetened).	0.8	11.0	10	18	0.3	100	0.09	0.02	0.2	42
Peach ...	0.5	12.0	8	22	0.6	880	0.02	0.05	0.9	8

Source.—Compos:tion of foods used in Far Eastern Countries Agriculture Hand Book No. 34 Bureau of Human Nutrition and Home Economics USDA, Washington, D.C. March 1952.

Furthermore four short course classes in fruit and vegetable preservation of 15 days' duration each both for men and women were also started at the Horticulture Section of this Institute. In addition seven months' Diploma Course in fruit and vegetable preservation was started to train some technical persons for the industry. The object was to increase the manufacture of these products on more scientific lines. It was the result of these efforts that at the time of partition (1947), there were 200 big and small frui and vegetable processing concerns.

Whereas the purpose of all this initiation by the Government was to bring down the wastage of fresh fruits, it was also the main object to supplement the daily diet of the people with nutrients.

If we compare the nutritive value of fresh fruits as well as preserved fruits, the loss of various nutrients of preserved fruits is negligible in some cases while in other cases such losses are so less that materially tne nutritive value is not lowered. The retention of nutrients in such products depends on many factors *viz.*, variety, maturity, harvesting methods, transportation, time taken between harvesting and processing, storage before processing, processing methods, packing and storing after processing and distribution methods. If all these factors are properly controlled and strict sanitation is employed in the premises, the real object of nutrient retention can be met to a great extent.

The inclusion of fresh fruits in our daily diet is based upon their value as sources of fluids, carbohydrates, minerals and vitamins. They are less important as protein or fat sources. Citrus and tomato juices supply a good amount of vitamin C while carotenes are present abundantly in coloured fruits. Some of the fruits are a fair source of water soluble 'B Complex' factors including riboflavin, thiamine, niacin, and biotin etc. Composition of some important fruits is given in the Table above.

Fruits and fruit juices are preserved by the following main methods:

(*i*) Canning.

(*ii*) Dehydration.

(*iii*) Low temperature:

(1) Cold storage of fresh fruits for short periods (at temperatures above freezing).

(2) Freezing.

(*iv*) Chemicals.

(*v*) Physical.

The first four methods or their combination are most commonly employed in various countries. In Pakistan only canning, dehydration and chemical preservation are the best used methods for the preservation of fruits and their juices. Short period storage of fresh fruits in cold storages located in big cities is also practised.

The need for preserving fruits was felt during the past years to check the wastage of fresh fruits during the glut of season. Some of the processing methods help in retaining much of badly needed nutrients. During the off season these nutrients can very well supplement our diet.

The nutritional properties of canned fruit juices depend on variety of the fruit, methods of juice extraction, straining, deaeration, heating, cooling, packing and storage. Published data from foreign countries indicate that no significant losses occur during the above processes provided properly adopted procedures are employed. Storage of canned products at a temperature lower than 50°F considerably helps in the nutrient retention. The retention of nutrients in canned fruits is also a function of processing treatments. Storage temperature and time also affect nutritive value of canned fruits.

Dehydrated fruits are also a good source of energy, minerals and some of the vitamins. Loss of vitamins during dehydration process depends on the treatments and methods employed. Published data agrees with the statement that dehydration results in better retention of carotenes, thiamine (if fruit not sulfured), riboflavin and ascorbic acid. Retention of these nutrients of course depends on various factors including handling, preparation methods and drying equipments used. Sun-dried fruits in addition to colour deterioration lose nutrients more than dehydrated fruits.

Freezing also retains more of nutrients in fruits. This retention again depends considerably on the preparation and packing methods as well as freezing techniques used. The temperatures at which frozen fruits are stored have a great influence on such retention.

Adopting, therefore, the best procedures in the processing of fruits and their juices always results in higher retention of important nutrients.

After the independence there occurred a great dislocation and the industry experienced a setback. The number of big and small fruit processing concerns during 1955 were 139 in West Pakistan. Due to partition there was a considerable decline in the garden wealth of West Pakistan. It was not actually up to 1950 that Government made efforts to increase area under fruit orchards in the country by supplying nursery plants at reduced rates as well as sanctioning enhanced water supply. Soon it was also realised by the farmers that per acre income from fruit garden was 3 to 4 times more compared to other crops. This, therefore, increased the total production of fruits in the country.

Though the production increased yet the transportation and market conditions were so worse that a considerable wastage again occurred. The Horticulture Section at the Punjab Agricultural College and Research Institute, Lyallpur again started Fruit and Vegetable Preservation Extension Service on the same lines as of prepartition days. This service was made more effective as fruit processors were also provided some advisory help.

The machinery in nearly 95% fruit processing concerns was hand working (same continues up to this time) where indigenous type of heating system (chullah) and aluminium utensils were extensively used. The daily output by each of such concerns was not more than 500 to 800 pounds of fruit products during eight hours working per day. The sanitary conditions were poor. It was during 1951 that Pakistan Government promulgated Fruit and Vegetable Products Control Order laying down sanitary standards, quality standards of fruit and vegetable products as well as building requirements for establishing such concerns. It was also due to untiring efforts of the Pakistan Fruit and Vegetable Preservers Association and their resourceful Secretary that Government allowed some facilities to this industry in the country. This was only in the form of a fixed monthly sugar quota to each concern according to its output capacity.

The need was again felt to rehabilitate this industry on sound footing in order to produce good quality products. This could not be done unless modern equipment, trained persons, some of the material like tin cans, chemicals and sugar were readily available. These items all required a considerable foreign exchange.

The object of such reorganisation was (*i*) to stabilise the growers' income (*ii*) to supply more nutrients to the consumer during off season as the fruits disappear from the market as soon as season is over (*iii*) to earn more foreign exchange for the purchase of processing equipment, sugar and tinplate. As far as nutritional aspect is concerned, it is clear that these supplement our daily diet if regularly taken. Still there is one objection that ordinary man cannot afford to buy canned fruits in off-season. The purchase of such product depends on the income of the people and living standard. Pakistan Government are making efforts to raise the standard of living of common people and increase their income as earmarked in the current five years plan.

Growers income can be well stabilised if their fresh produce gives them a better return instead of rotting some portion of their produce due to bad conditions in the markets.

Let us survey the potentialities of export of our fruit products. During 1959-60 the export of dried fruits including artificially dehydrated fruits was worth 13,63,000 rupees while preserved fruits and other fruit preparations were of the value of 6,000 rupees. During the period July, 1960 to June, 1961 fruits and fruit preparations worth 19,37,000 rupees were exported.

In some of the Middle East and South East Asian countries there is a great demand of preserved and dehydrated fruits. Trade enquiries received by the Department of Trade Promotion and Commercial Intelligence, Karachi show that certain foreign firms are interested in importing commodities including fruit products from Pakistan. Arabian Gulf required dry fruits and preserved vegetables and similarly Saudi Arabia required food stuffs and fruits as appeared in the 'Pakistan Trade', February and March 1961 issues. For the requirement of an average consumer in Sudan the following items among others were allowed for import into that country under their OGL system. This included the following: apples, dried figs, raisins, currant sultanas, dried fruits, jams and marmalades, tinned fruits and apricot paste. There is a great demand of dried fruits and concentrated fruit juices in U.K.

Every pound of fruit either fresh or processed which is exported in return can bring us more needed modern sanitary equipment as well as tin cans from foreign countries. This can ease the present bad plight of this industry in the country. The Pakistan Fruit and Vegetable Preservers Association after a very long effort induced the Pakistan Government to allow some foreign exchange initially for this purpose.

During the current five years development programme an estimated sum of nine million rupees privately financed has been included for modernizing existing plants as well as establishing new fruit and vegetable canning and preservation organisations.

The object of all this expenditure is (*i*) to adapt this industry to changing economical and technical conditions (*ii*) to encourage the processing of fruits thereby avoiding wastage of fresh fruits, (*iii*) to create additional employment opportunities and in creasing income of the people.

Government showed a keen interest and attached a great importance to the development of small industries. The Pakistan Government announced through a Gazette notification December 12, 1960, the small industries schedule for the private sector. This was the first time that such an encouraging step was taken. The schedule provided local as well as foreign exchange components of cost under each industry. The following allocations in the schedule were available for financing either new units, balancing or modernization of existing capacities regarding fruit and vegetable canning. The schedule included 8,00,000 rupees as internal cost and 35,00,000 rupees as external cost.

Considering the requirements of fruit products in the country it is reported that

during 1954 the production of canned fruits was 8,40,000 lbs. as against the requirement of 8,80,000 lbs. Similarly bottled products were 16,10,000 bottles against the requirements of 35,20,000 bottles. The installed total capacity was not fully utilized. In order to meet this deficit artificial sherbets (containing no fruit juice but only essences in sugar syrup) are mostly consumed by the general public. These types of beverages are able to quench the thirst during hot days but no useful nutrients are supplied to the body. In addition to civilian demand, armed forces of Pakistan require a variety of fruit products in thousands of pounds yearly.

Besides this no frozen fruit products are being produced commercially in the country. Sun-dried fruits like dried apricots, dried figs, dried grapes, wet dates (cured in the sun) etc., are available in the country. The quality of these products is very inferior in respect of their colour, shape, texture and flavour. These defects lower their price in the country as well as the export potentialities are decreased. Last year a huge capacity dehydrator has been installed at Nassarpur near Peshawar. It is expected that good quality of dried fruits will be made available at a reasonable price in the country. Concentrated fruit juices are also in big demand in the country but one fruit processor at Renala Khurd is unable to meet the whole demand.

Though it is estimated that total installed capacity for the preparation of fruit products (except juice concentration) is very high, yet annual production always remained low. There are many factors responsible for low production of fruit products. Some of these are discussed as under:

(*i*) *Transportation.*—Fresh fruits from producing centres and orchards to consuming centres are transported by one of the following means according to the distance to be covered:

(*a*) human labour.
(*b*) animals.
(*c*) animal driven carts.
(*d*) lorries.
(*e*) rail.
(*f*) air.

For transportation of fresh fruits by rail ice cooled vans are used. No mechanical refrigeration system is employed. During the glut season, as the number of such vans is limited, the demand of fresh fruit transportation becomes very high, the railway cannot ship all the required fruit in such vans. Extra fruit packages are piled up in these vans making it difficult to preserve their quality through long distance travel. Goods wagons are sometimes used for this purpose. During hot season the temperature rise inside is so high that fruits become over-ripe and loose original quality. Transport of fresh fruits by air is very costly and very delicate fruits are carried by this mean.

The use of other means for short distance transportation also result in losses due to (*a*) unfavourable conditions in the markets (*b*) unsuitable containers used for packing fruits.

(*ii*) *Storage.*—In order to enhance the life of fresh fruit it is necessary that heat of the fruit must be extracted as soon as possible. This slows down the respiration rate and enzymatic reactions. This results in retaining the fresh qualities of the fruit for a longer period. The use of the fruit therefore can be spread over a longer period. The prices can also be regulated.

Due to lack of cold storage facilities at the market sites, the fruit in bulk cannot be handled for more days. Most of the processors who purchase fruit from the market for their purpose can prepare fruit products only during these short days of supply depending on their installed capacity.

(*iii*) *Markets.*—The conditions in the fresh fruit markets are well known to every person in the country. During rainy season the open place in markets (where such commodities are auctioned) is so stuck with mud that it even becomes difficult to enter there. No arrangements are made for disposal of rain water. The places therefore contribute more microbes thereby increasing the initial load.

(*iv*) *Trained Persons.*—The fruit processing concern except one in the country are without any qualified person in the subject. The knowledge of most of the processors rests with the home scale preparations of fruit products acquired by attending 15 days short course classes in Fruit and Vegetable Preservation at the Punjab Agricultural

College and Research Institute, Lyallpur. These courses do not provide them any bacteriological or sanitary background for processing of fruits.

With the cooperation of ICA (USOM-PAKISTAN) under Inter College Exchange Programme, arrangements were made to develop a Food Technology Division at this Institute. The first object of such development was to provide trained persons to the industry. To meet this object, courses are now given in Food Technology covering various aspects and different foods. Such courses are imparted to students at the graduate as well as postgraduate levels. These courses are supplemented with practical training to the students on the preparation of canned, dehydrated, frozen and other preserved foods. For this purpose the pilot plant at the institute is equipped with modern machinery purchased from U.S.A. under the above project. Along with the preparation of the food products, quality control subjectively and objectively form also another part of the practical training to the students.

It is expected that some of the well-trained persons in Food Technology on graduate and postgraduate levels will be available this summer to help the Industry. In addition to these regular courses, a two months Industrial Course in Food Processing is also conducted every year at this institute. This course is intended specially for those persons who are working in any food industry in the country. Plant foods processing cover a major portion of the course. This training provides a fair knowledge to the students regarding principles of good processing and sanitation requirements.

Besides modern equipments and machinery, the Food Technology Division at this Institute is also staffed with foreign trained persons. It will not be out of place to pay tributes to Professor Clyde W. Eddy (late) for his untiring efforts for the above developments.

Under the present contract (West Pakistan Agriculture University and Washington State University) this division will be constantly guided by the presence of Dr. A. O. Shaw at this University and Dr. M. J. Powers at Washington State University, Pullman, Washington, U.S.A.

(*v*) *Availability of Glass, tin Containers and other Chemicals.*—In Pakistan sanitary tin cans are not prepared but supply of such is all met through imports. Though the position has been eased by substantial imports of sanitary tin cans., yet the cost is high. M/s Hashmi Can Company, Karachi are the sole agents of M/s Metal Box Co., London dealing in the preparation of such cans. Sanitary cans of different sizes in the folded condition are shipped to Pakistan. These are then reformed, flanged, and bottom end fixed in the processing factories. Some factories have got these arrangements but others do not have. Those which do not have these arrangements get their supply of tin cans with bottom end fixed. Efforts are underway to arrange machinery in Pakistan for fabrication of tin cans from imported tin plate.

M/s Hashmi Can Company, Karachi have only general can manufacturing arrangements. Chemicals like citric acid, potassium metabisulphite etc. are also to be imported.

Various firms in Pakistan are now manufacturing glass bottles and jars suitable for fruit products required in the country. There is a steady improvement in the quality of glass manufactured every year in the country. Some of these containing fruit products are shipped abroad.

(*vi*) *Sugar.*—So far due to low production of high quality sugar in the country, the deficit was met by importing a substantial amount. Fruit Processors were getting sugar quota on quarterly system for the manufacture of products according to their capacity. From this year as the country made high quality sugar is available the position of fruit products manufacturing will become more secure if its price goes further down. The success of competition in the foreign markets of fruit products depend on high quality and low price.

(*vii*) *Research.*—Before partition a good deal of work was conducted at this institute to standardise different fruit products. After independence due to shortage of modern equipment and trained persons this work could not be conducted to the full extent. With the establishment of Food Technology Divisions in the Research Laboratories of the Pakistan Scientific and

Industrial Research Council at Karachi, Lahore and Peshawar in West Pakistan and Food Technology Division at this institution, it is hoped that gap created in the research sphere would be very much filled.

In the country though different varieties of one fruit are available, but still it is not known how one variety behaves towards canning, dehydration, freezing or the preparation of other products. The next point requiring investigation is the effect of various cultural practices, climate, soil and various fertilizers on the quality of fruit products. In addition to glass, there are other packing materials available in the country. Effect of these packages on the final quality and stability of some of the products, effect of processing methods on the quality of the products need investigations. Preparation of some of the new products like fruit juice concentrates; fruit juice powders, fruit candies, require an immediate attention of research workers.

It should not be a drain on the Government treasury to carry on above research work. The industry can benefit more if some of the projects concerning their problems either individually or collectively be financed either wholly or partly.

None of the food processing concerns in the country have facilities for research or quality control work. As they cannot assess the final quality of their products, they cannot judge whether the product going into the consumer hands be acceptable. This requires a thorough consumer acceptance and laboratory tests before putting the product in the market where there is competition from other firms displaying the same type of products.

Before independence work on cold storage of different fruits was conducted by the Horticulture Division at the Punjab Agricultural College and Research Institute, Lyallpur. Different varieties of fruits grown in the former Punjab were tested for their optimum time and temperature of storage at low temperature above freezing. This work was conducted on laboratory scale at that time and some of the deciduous fruits tested were mainly grown in East Punjab (India). As the number of cold storages and their capacities are increasing in the country it is more desirable to take up this work involving different fruits grown in Pakistan specially those developed after partition. Most of the cold storages in big cities only store seed potatoes and some of these are also taking up storing of fresh fruits at low temperatures.

From this discussion it is evident that scope of fruit preservation in the country is increasing even there are some difficulties. In most of the cases the Government is helping the industry by providing foreign exchange to some food processors who are really keen to modernise their existing plants. By providing this facility the Government is very keen to get the answer that how much quantity o fruit products specially and other food products in general would be exported by the firms. To meet this demand it is necessary that products manufactured in the country should be of high quality which can compete fairly well with the products in foreign markets. These should also be of low price. Those manufacturers who are quite new in this business are unable to produce such foods for foreign countries.

Those processors who have long standing in the business, have got well qualified persons and already producing good quality products for home consumption may be given priority for modernizing their existing plants.

This new machinery will reduce excessive handling of the products during processing increase daily output and lower the production cost. This is one way for the manufacture of good quality products. It does not mean that only some firms be favoured with such facilities but chances must be open to other firms. Small concerns must be encouraged to produce high quality products for consumption within the country.

It is again not always necessary that each firm should contemplate to take up the responsibility of producing all types of fruit products. Such organisations coming forward to specialize in one or two products must be encouraged by the Government by providing necessary facilities to them. They should concentrate on these products and improve their quality. Special lines of production may include any one of the products *viz.*, concentrated fruit juices, processing and packing of sun-dried as well as dehydrated fruits and freezing of some

fruits. These products will find a ready market within the country.

Improvement of fruit products quality demands standardization from the raw material up to the final processing and packing. Standard specifications should be formulated for all the ingredients and raw materials required for the production of these products. These standards will then provide information regarding form, size, finish and composition of the products. On one hand standardisation will enhance the quality of fruit products but on the other hand it has also following advantages;

(*a*) Fewer disputes between buyer and seller.

(*b*) Greater availability of products of same quality.

(*c*) Provides sound basis for comparison.

(*d*) Provides effective protection to consumers against purchase of inferior commodities.

(*e*) Increases income, improves quality.

(*f*) Reduces cost.

The success of standardisation depends on how the manufacturers and producers co-operate. A committee appointed under the Food and Agriculture Division of Pakistan Standard Institute is dealing with the standardisation of food products. This committee is comprised of persons of high caliber dealing with different foods in Pakistan drawn from research institutes and Government Departments and well qualified representatives of the industry. In order to enforce these standards more effectively it is necessary that these be made compulsory for all food manufacturers. Fruit products will cover a major portion of these standards.

In order, therefore, to improve on quality of fruit products where modernization to the existing plants is advocated it is also necessary that the quality of fresh fruits be controlled. If we start with a good quality raw material we will end with high quality product.

The fruit after harvesting should be immediately processed. If the time between harvesting and processing is longer fresh fruits must be stored at low temperature. Such cold storage facilities be provided either at the market sites, near orchards or at the factory site.

As the location of orachards in one area of the country is scattered it will be more economical if cold storages on co-operative basis are installed in different areas. The produce from these scattered orchards can then be stored in cold storages of the respective areas. These organisations will make arrangements for grading, storing and disposing off the fruits. The growers can be paid according to grades after deducting handling charges. This will also insure supply of good quality fruits to the manufactures over a long period. Mechanical refrigerated trucks or railway vans are the other necessity for transporting fresh fruits to long distances.

The scope of this industry can be based on a very sound footing and enhanced if improvements in processing methods and handling of raw material are being constantly made. For this purpose the existing conditions in the fruit markets, sanitary conditions in the processing factories be improved. Further to increase the scope of this industry, the processors should always aim at producing new products and improving their existing products. The mass production o new fruit products always requires a very thorough planning. Consumer testing of such products in different areas of the country is the best technique for safeguarding the future interest of the organisation before these are actually displayed for sale in the open market.

The demand of such products by the people is now increasing. These products in addition to supplying nutrients and variety of fruits in off-season, are also a good source of foreign earnings. In order to make it a flourishing business the Government is also urgently requested to consider giving some rebate to the processors against the products which may be exported by them. This will compensate them for the high price of sugar and containers used in the processing of such products.

RECOMMENDED VARIETIES OF MANDARIN
(CITRUS RETICULATA)

BY
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Mandarin (Sangtra) is somewhat catholic in its climatic requirements as compared to sweet orange (Malta). It requires somewhat humid and milder climate. In former province of Punjab where hot and dry weather prevails, famous sangtra varieties do not do well. Nagpur sangtra with its thin peel has the tendency to bear its fruit on periphery and thus remains exposed to hot and scorching sun rays. Fruit is spoiled by sun burn. The appearance of the fruit is marred with dried up pulp. The fruit cannot be marketed since it does not remain wholesome.

Desi sangtra produced in the province is of poor quality with loose skin and sour taste. In order to find an answer to the problem a large number of exotic varieties were collected and tried at Government Experimental Fruit Garden, Lyallpur. The introductions were made from countries like U.S.A., Australia, Japan, South Africa and Indo-Pakistan Sub-continent. This endeavour bore fruit and it has become possible to recommend to the fruit industry two mandarin varieties, excellent in quality and most outstanding in other aspects. Such an eye appeal, bearing potentialities, adaptabilities to our soil and climate conditions. These two varieties are kinnow and Feutrell's Early, and now make the backbone of citrus fruit industry in the former province of Punjab. Both these varieties bear fruit inside the foliage which remains protected from sun rays. Their peels are somewhat thick, that also provides protection against sun burn and other vagaries of weather.

The salient features of these two mandarin varieties are very briefly given as follows:—

Kinnow

Tree. Tree of kinnow is medium, columnar with compact round oblong head. Leaves are medium and are of dark green colour.

Fruit

Size of the fruit is medium to large. Shape is round to round oblate. Skin is smooth, tight, adhering to flesh.

Fruit Quality

1.	Colour of the fruit.	... Cadmium yellow orange.
2.	Surface	... Glossy and smooth.
3.	Average size	... 7.8×6.1 cms.
4.	Rind	... Medium thick.
5.	No. of segments	11
6.	Pulp	... Deep yellow orange, melting.
7.	No. of seeds	... 23.6
8.	Juice percentage	50
9.	Acidity	... 0.54%
10.	T.S.S.	... 14.5%
11.	Ripening time	... February.
12.	Average yield per tree.	... 520
13.	Remarks	... This is a tight skinned mid season variety which ripens in February. Pulp is very fine with excellent taste and a special aroma. Its pulp melts when placed on the tongue.

Feutrell's Early

Tree. Tree is medium, growth compact, with plenty dark green foliage. This is an early variety which ripens in November,

hence fetches good price in the market.

Fruit

Fruit is medium in size and oblate in shape. Colour is attractive golden red. The skin is tight which adheres to flesh.

Fruit Quality

1. Colour of the fruit... Grenadine red.
2. Surface ... Smooth.
3. Average size ... 6.4 × 5.1 cms.
4. Rind ... Thin and firmly attached.
5. No. of segments ... 10
6. Pulp ... Very juicy.
7. No. of seeds ... 15.2
8. Juice per.entage 48.4%
9. Acidity ... 0.35%
10. T.S.S. ... 13%
11. Ripening time ... November.
12. Average yield per tree. ... 500
13. Remarks ... Being an early variety it captures market, hence is very popular among the fruit growers.

POTATO—AS FOOD IN REPLACEMENT OF CEREALS

BY

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The potato outranks all other vegetable crops in economic importance. It is native to South America and was first introduced to Europe by the Spaniards in the sixteenth century. Drake is supposed to have carried potatoes from the West Indies to Ireland in 1586. In 1719 Scottish-Irish immigrants to New Hampshire introduced the potato to the North American Continent. There is no historical evidence to show as to when potatoes were introduced to Indo-Pak sub-continent, but it can be said that potatoes are being cultivated here for not less than half a century. Introduction of this crop into the areas now constituting West Pakistan is not so old. New impetus has been given to the cultivation of this crop since the time of establishment of Pakistan.

About a hundred years elapsed before the value of potato as a food crop was appreciated. The potato was found to be the most important factor in curbing famines that formerly devastated Europe and today serves as the most important carbohydrate food crop of densely populated temperate lands. In the eighteenth and nineteenth centuries when potato became the major source of food in a large part of Europe, its two principal disadvantages -bulk and comparatively short storage life as compared with grains-became apparent. In Europe, experiments with various types of dried potato were made in the latter half of the eighteenth century partly with a desire to increase the usefulness of the tuber as Ships' provisions. A sample of potato flour or meal was prepared in 1786 that "keeps sound for any length of time" (Fraser, 1794).

As pointed out above, potato has been playing an important role in the economy of food in different parts of the world. A few of the disadvantages experienced in the past with regard to utilisation of potato as food are being eliminated by the use of knowledge and experience of handling and processing of this important crop.

Because of limited resources for land and other agronomic factors and also because of day-to-day population pressure on land, the food shortage has become a permanent feature and a source of peculiar headache for the Pakistani people in general and that of Government in particular.

It has been estimated that Pakistan will have to import 4 lakh tons of foodgrains annually from abroad to meet this shortage. Heavy drains on our foreign exchange in this direction must seriously hamper our agricultural and industrial development programmes and, consequently, the economic development of the country. It is high time that concerted efforts be made to solve the perpetuating food problem as quickly as possible. The various approaches for the possible solution of this problem are: protection, orderly distribution and proper utilization of the food produced; increasing production per unit area; and above all by changing the crop pattern—replacing low yield crops by high yield crop.

At present we are mainly concerned in changing the crop pattern and also make the people potato minded. For this purpose we must examine the status of potato in the way of per capita consumption. This is given in Table 1.

TABLE 1

Per capita consumption of potatoes, pounds, selected countries for 1948-49

Country	Per capita consumption
Germany East	479.9
Germany West	438.5
Ireland	428.8
France	316.1
Poland	528.4
Finland	405.7
Belgium	311.1
United States	96.8
Pakistan	12.0

It is quite obvious from the above figures that per capita consumption of potato is far less in Pakistan as compared to other countries of the world.

While recommending the utilisation of potatoes as partial replacement of cereals, we must take into consideration the nutritive value of potato as compared to wheat. The food composition of potatoes, wheat and sweet potatoes are shown in Table 2 for their comparative study.

A glance at Table 2 would indicate that the potatoes contain higher percentage of minerals than either wheat or the sweet potatoes. Potato provides a good source of iron. Analysis has shown that 97 per cent of the iron in boiled potatoes was present in an available form. An interesting feature of the table is that wheat and sweet potatoes lack the necessary vitamins which are essential for the upkeep and a normal function of the body.

Before the modern era of abundant fruit in Europe and America, the chief food that protected man against scurvy were cabbage, potatoes, tomatoes and apples. The value of the potato is quite evident and impressive. It is easy to understand why nutritional diseases are not associated with potato eating areas.

Foods have long been studied in relation to their acidity or alkalinity when burned in the body. If a food such as meat contains an excess of sulphur and phosphorus, these are oxidized to acids and the food has an acid ash. If a food such as potatoes is burned it ends as an alkaline ash because it has an excess of alkaline constituents such as potassium. Potato is among the alkaline foods while meat, eggs, rice and bread are among the acid ones unless the bread is made with large amounts of potatoes or milk.

TABLE 2

Composition of foods 100 *grams edible portion*

	Water	Food Energy	Protein	Fat	Carbohydrates	Calcium	Phosphorus	Iron	Vitamin A	Thiamine	Ascorbic Acid
	Pct.	Cal.	Gm	Gm	Gm	Mg	Mg	Mg	1. M.	Mg	Mg
Raw—											
Potatoes ...	77.8	83	2.0	0.1	19.1	11.0	56	0.7	20.0	0.11	17
Wheat ...	11.0	335	9.4	2.0	75.4	36.0	394	3.0	0	0.53	0
Sweet ...	68.5	12.3	1.8	0.7	27.9	30.0	49.0	0.7	7.7	0.9	23
Sweet potatoes											
Dehydrated—											
Potatoes ...	7.0	357	7.1	0.7	82.2	25.0	88.0	4.0	40.0	0.3	23
Wheat ...	...	...	...	...	...	...	...	...	...	...	...
Sweet potatoes	7.0	362	5.0	0.9	84.5	75	74	23	19.7	0.2	32
Flour—											
Potatoes ...	7.0	357	7.1	0.7	82.2	25.0	88.0	4.0	40.0	0.3	23
Wheat ...	12.0	333	13.3	2.0	71.0	41.0	37.2	3.3	...	0.55	...
Sweet potatoes	...	...	...	...	...	...	...	...	...	...	...

The human diet is seldom lacking in phosphorus, so one seldom pays attention to this unless it occurs in the form of phytin and in a food low in calcium, such as wheat. Phytin is found mostly in cereal grains. Phytin has special interest when diets are low in calcium, because it tends to tie up and waste the calcium in the diet through excretion. Experiments on feeding rats at Cornell University indicate that rats fed the diet rich in potatoes had the best survival and superior quality of bones in old age and they had greatest mean span of life. Hence it means that man has some power to pre-determine the quality of his skeleton in old age.

As far as potato flour is concerned its use in bread making goes far back into history. Bakers have traditionally used pealed, cooked and mashed potatoes to impart flavour and improve retention of refreshness in their bread. Potatoes have long been recognised as an excellent yeast food. It helps materially to preserve freshness due to increased water absorption afforded by potato flour. Most of the carbohydrate in cooked potato flour is starch, all of which is gelatinised and in rather soluble form. The protein present is also mostly soluble. Valuable mineral substances, particularly the potassium, magnesium and phosphorus, essential in stimulating yeast growth, are present in amounts adequate for vigorous fermentation. The value of active fermentation in bread cannot be over-emphasised. A vigorous evolution of carbon dioxide is required to give the desired porosity and texture in bread. The constituents of potato are recognised as outstanding among bread ingredients for their activity to stimulate growth of yeast cells and activate fermentation of sugar.

The generally accepted level of potato flour in potato bread is 6 per cent in America. An introduction of potato crackers was an indication that the use of potato flour by the baking industry is not confined to bread alone. The special cracker, resembling a potato chip in texture and flavour contains 12 to 20 per cent of potato flour. The use of potato flour in soda, graham and other crackers offer a number of advantages, including mere complete fermentation, greater bloom and flavour intensification. In addition potato flour is used for pastries, yeast raised doughnuts, cakes and cake mixes. One of the largest virtually untapped outlets for potato flour is the cookie industry. Up to 5 per cent is added to all standard type cookies. Potato flour is also used as a breading meals. Frozen fried chickens and sea-foods are now breaded commercially with potato flour.

A partial list of other end products containing potato flour would include dehydrate, frozen piefillings and crusts, baby animal feed etc., where the flour is used as a combination thickener-flavouring agent, such as gravies, sauces and baby foods.

In addition to comparing food values of equal weights of potatoes and bread it may be of interest to compare the relative amounts of the two kinds of food produced by an acre of land assuming the climate and soil to be identical for potatoes and wheat. Under these circumstances we may expect a yield of about 150 maunds of potatoes and 12 maunds of wheat per acre under irrigated conditions.

It is evident from the above table that wheat grown under irrigated conditions yielding 12 maunds per acre on an average in West Pakistan produces 15,47,272.9 calories, when caloric value of 1 lb is 1,566.7 units. Potatoes, on the other than, yielding on an average 90 maunds per acre in autumn crop produce 2.15 times calories and in spring crop yielding 60 maunds per acre on an average, give 1.44 times calories as compared to wheat. Since both the autumn and spring crops can be grown one after the other on the same field in plains during the growth period of wheat, it means that an acre under potato is capable of producing over three and a half times as many calories as when under wheat. In other words, there is a net gain of 2½ times the calories value of wheat.

We can conclude from the comparative study of composition of food of potato and wheat that the former offers as good a nutritive value as that of wheat. Potato being rich in alkaline elements and essential vitamin contents can partially replace wheat in our diet and produces 3.6 times the calories in wheat per acre. As such we can increase our food production immediately for our population. Besides, it is twenty times profitable for the cultivators to produce

potatoes than wheat. A shift from wheat to potato cultivation is therefore imperative.

It is in the interest of nation and people of Pakistan to take to potato utilisation for combating the food shortage situations. This would benefit the growers and the consumers. Qureshi (1958) states that cost of production of potatoes is Rs. 4.06 per maund as against wheat which is Rs. 9.9 The net income from an acre of wheat is Rs. 62.31 and for that of potatoes is Rs. 1286.6. Our need at this time is to produce enough calories for the population to subsist and in growing more potatoes we have an answer.

Potato has been most advantageously used for averting food prices elsewhere. It has been said that Germany fought her first world war by increasing her food supplies by producing more potatoes. With the increase in population, European countries solved their food problem by resorting to potato cultivation. The notorious famines have disappeared from Ireland ever since they have started potato cultivation. Java, when she could not support her thick population on cereals etc., resorted to cultivation in tuber crops like potato and sweet potato which now excel in area as compared to any other crop. In Austria and Czchoslovakia, potato occupies nearly as much area as under wheat. It is good that experience of other countries be used to advantage and fillip given to potato cultivation.

Potato can be used in several ways. The use of a few dishes out of these are, mashed potato, French fries. American fries, potato chips, etc., may be adopted. In India, potato flour is being mixed with wheat flour in some rationed areas. Potato can easily be introduced in military ration and in fact it is being done to some extent. This can be further extended to institutions like jails, hospitals, school and college hostels, hotels, etc. For the public at large demonstration of different uses may be given on suitable occasions. Radio service and film industry in the country can also be made use of to a great extent.

It appears from the foregoing discussion that there cannot be any danger of overproduction of potatoes in West Pakistan. What we actually need is to supply potatoes at cheaper rates to the consumers. This can be done by reducing cost of production, persuading growers to charge less profit, increase production and supplying the growers varieties of potatoes resistant to frost with good agronomic factors. In the latter case the growers will be in a position to grow a normal crop of potatoes like wheat which they have to otherwise split up into two crops because of their susceptibility to frost.

The Potato Botanist, Murree, is concentrating to evolve frost resistant varieties of potatoes and he has certain valuable crosses under observations to this effect.

FOOD VALUE OF VEGETABLES

BY

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Vegetables constitute a definite class of Horticultural plants grouped and defined on the basis of their use. A vegetable is usually an edible herbaceous plant or part thereof that is commonly used for cooking purposes. It is obvious that edible portion of vegetables may be fruits, foliage, tubers, roots, etc. There are plenty of exceptions even to this broad classification Lettuce leaves and fruits of watermelon and muskmelon are taken raw as such, but these are still defined as vegetables. Over a thousand species of herbaceous plants are frequently eaten in the world and are properly classed as vegetables.

The phenomenal growth of vegetable cultivation is due in a large measure to the recognized food value of vegetables. The vegetables are most important source of vitamins and minerals. The specific needs including vitamins and minerals for a moderately active person of 140 lbs include 3,000 calories, 70 grams protein, 0.8 grams calcium, 0.8 grams phosphorus, 12 milligrams iron, 0.1 milligram iodine, 5,000 international units vitamin A, 1.8 milligrams vitamin B_1, 2.7 milligrams vitamin B_2, 75 milligrams vitamin C and 18 milligrams nicotinic acid.

In addition adults require approximately 10 grams salt, 3.0 grams potassium, 0.3 gram magnesium, 2 milligrams copper, 1.5 milligrams manganese and traces of zinc and cobalt daily.

Vegetables as a source of carbohydrates and proteins

Potatoes and sweet potatoes have high quantity of carbohydrates *i.e.* 19.1 per cent and 27.1 per cent respectively and each have 85 and 125 calories in every 100 grams of edible portions. These tuber crops form a much higher proportion of daily food of people in European countries as well as in America. The consumption of potatoes is estimated to be about 12 lbs per head per annum in Pakistan against about 200 lbs or even more in some of the advanced countries of the world. This is due to the fact that they are not sufficiently cheap in Pakistan and are mainly used in place of pot-herbs and not as a source of energy in place of cereals. Dried seeds of beans and peas are rich in proteins containing 22.0 per cent and 23.8 per cent respectively.

Vegetables as a source of vitamins

Vitamins may be defined as chemical compounds essential for life formed from ammonia by replacing hydrogen atom with alcohol or other base radicals. Vegetables and fruits are the biggest source of vitamins particularly green leafy vegetables. The approximate composition of edible portions of vegetables is given on next p ge.

Vitamin A

It only exists in food of animal origin, but its precursors are found in plants which are converted into vitamin A in the body. These precursors are a-carotene, b-carotene, r-carotene and cryptoxanthin. The chief function of vitamin A is to prevent night blindness, opthalmia and infections entering through epithelia. Pro vitamin is concentrated in

Vitamin content of different vegetables
Vitamin value per 100 grams of edible portion

S. No.	Vegetable	International Units		Sherman Units	M. G.
		A	B_1	B_2 (G)	C
1.	Beet root ...	50	17	50	10
2.	Cabbage ...	400	27	60	100
3.	Cauliflower ...	70	56	60	75
4.	Carrot ...	10,000	23	50	11
5.	Cucumber ...	35	30	60	11
6.	Lady's Finger ...	2,300	42	...	15
7.	Muskmelon ...	2,000	19	30	37
8.	Onion ...	...	10	40	14
9.	Peas dry ...	5,000	180	125	...
10.	Peas green ...	2,000	130	125	100
11.	Potato ...	50	62	31	28
12.	Pumpkin ...	2,500	18	40	10
13.	Radish ...	10	30	14	26
14.	Spinach ...	10,000	35	150	112
15.	Sweet Potato ...	4,200	31	33	32
16.	Turnip ...	15	20	21	24
17.	Tomato ...	2,000	26	36	30
18.	Watermelon ...	2,800	24	14	25

leafy portions of vegetables. These also exist in carrots and yellow sweet potato.

Vitamin B

It has two major groups namely vitamin B_1 or thiamine and vitamin B_2 or riboflavin. Vitamin B_1 is anti-beri vitamin. Vitamin B_2 is effective in preventing baldness, cataract, etc. All the vegetables are good source of vitamin B but these are frequently lost when water used for cooking is discarded.

Vitamin C or Ascorbic Acid

It prevents scurvy. It is readily lost by oxidation when the vegetables are prepared in open containers. Leafy vegetables including Muskmelon and Watermelon are good sources of vitamin C.

Vegetables as a Source of Minerals

Vegetables are also among the most important source of minerals including calcium, phosphorus and iron. The green vegetables are good source of these mineral elements. Potatoes, sweet potatoes and mature onions contain appreciable quantities of phosphorus. The mineral content of different vegetables is as on next pa_e.

Vegetables as sources of roughages

A certain quantity of bulky food is necessary for good health. Vegetables are the main source of roughages for proper working of digestive machinery and form the alkali reserves of the body. In the course of digestion meat and other proteins there is increase in body acidity and this is neutralised by the alkaline reaction of the body. Cabbage, spinach and lettuce are characterized by high water content and relatively high percentage of cellulose or fibre. Because of their succullence of relatively large bulk, the leafy vegetables and most of the root crops a d in the digestion of the more concentrated food.

Reference

Vegetable Science by Brown and Hutchinson.

Minerals content of vegetables
Mineral content (mean value)

		MOISTURE FREE BASIS						
S. No.	Vegetable	Percentage				Parts per million		
		Ca	P	K	S	Fe	1	Cu
1.	Beet root ...	.19	.27	2.17	.13	133	.241	10
2.	Cabbage ...	.73	.38	2.71	1.16	205	.218	15
3.	Cauliflower ...	.53	.76	3.58	1.07	177	...	36
4.	Carrot ...	.40	.133	2.10	.16	192	.309	11
5.	Cucumber ...	.74	.75	4.48	.28	270	.226	50
6.	Lady's Finger ...	.72	.62	...	...	108	.697	9
7.	Muskmelon ...	.24	.21	4.62	.01	168	.230	6
8.	Onion ...	.39	.25	1.52	.60	130	.188	12
9.	Peas dry ...	.92	.44	...	.15	64	.097	16
10.	Peas green ...	.19	.57	1.41	.13	126	.009	9
11.	Potato ...	.049	.25	2.25	.12	85	.238	22
12.	Pumpkin ...	.50	.24	2.47	.10	115	...	11
13.	Radish ...	.29	.41	4.20	.59	463	.994	29
14.	Spinach ...	1.21	.72	6.16	.39	1319	9.382	44
15.	Sweet Potato ...	.08	.12	1.21	.22	70	.092	4
16.	Turnip ...	.51	.36	2.77	.43	92	.484	9
17.	Tomato ...	.24	.55	4.87	.32	202	.233	14
18.	Watermelon ...	.13	.04	3.00	...	109	.402	9

FROST, DROUGHT AND HEAT RESISTANCE STUDIES IN POTATO IN WEST PAKISTAN

BY

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Potato botanically belongs to genus Solanum L. and natural order Solanaceae. It is claimed by Hawkes (1944) that genus Solanum L. contains about 2,000 species of which about 150 are tuber bearing.

Potato is a native of South America and thrives best in cool, humid climate. It was introduced in Indo-Pakistan sub-continent from the Cape of Good Hope and Major Young was the first man to take up its cultivation near Dera Dun in the beginning of nineteenth century. From there its cultivation spread to different parts of the country.

In West Pakistan three crops of potato are grown one after the other *viz.*, the summer crop at hills, the autumn and spring crops in plains. According to established practices the summer crop is sown at hills in the month of April. Seed rate is 14 maunds per acre and the tubers are sown on flat. Earthing up is done when the plants are 8 to 10 inches high. The crop is harvested by the end of September. Average yield per acre is 80 maunds. The crop is very little manured *i.e.* 3 to 4 tons of Farm Yard Manure and still the people follow very exhaustive rotation Maize-Potato-Maize-Potato. Each crop has a duration of one year.

The autumn crop is sown in the month of September in plains. Seed rate is 20 to 30 maunds per acre. Weeding and hoeing is done after one month and this is followed by earthing up. The crop is heavily manured, *i.e.* about 30 to 40 tons of well rotten manure before sowing and 3 maunds of ammonium sulphate are added at the time of earthing up. The crop is harvested in the end of December and the yield is about 200 to 250 maunds per acre. The same fields occupying the autumn crop are immediately prepared for sowing spring crop. The sowings are completed by 5th to 15th January or at the most 20th January. The seed rate per acre is usually 12 maunds and all the tubers are cut before sowing. Fertilizer is applied to the crop at the rate of 3 maunds per acre at the time of sowing and 3 maunds at the time of earthing up. The crop is harvested by the end of April and the average yield is 100 maunds per acre.

There are definite problems concerning the plain crops. The autumn crop starts comparatively in long days with high temperature and ends in short days with low temperature and frost. The spring crop on the other hand is sown in short days with low temperature and is harvested in long, hot and dry days. Generally the late monsoon rains and floods delay the sowing of autumn crop. Similarly the untimely winter rains hinder the sowing of spring crop at the proper time. In such events the autumn crop is badly affected by frost and the spring crop suffers from heat and drought which reduce the yield considerably.

The improvement work in any crop can be taken up provided it flowers and forms viable seed. Potato breeding work under natural conditions can be carried out successfully at Murree in Pakistan. The potato species exist in five classified units according to their number of chromosomes ranging

from $2n=24$ to $2n=72$. Some of the wild species like S. commersonii, S. acaule, S. andigenum and S. demissum have all the desired characters *viz.* frost, drought and heat resistance. The interspecific crossing work in potato was taken up at Murree in the month of July, 1957 when the plants flower profusely. The following observations were recorded:—

(1) Reciprocal crosses were only possible in S. andigenum and S. tuberosum.

(2) S. demissum and S. acaule when crossed with S. tuberosum formed berries only when used as females.

(3) Back crosses with S. tuberosum formed more number of berries than interspecific crosses.

Frost Resistance

In fact such experiments like frost, drought and heat resistance should be taken up only in green house. Since no such facilities existed, some other methods had to be adopted. The frost resistance character was determined by sowing true seed of different varieties of S. tuberosum, wild species and their crosses on 1st July, 1957 at Murree in the nursery. The plants were transplanted in bigger pots on 1st August. These plants made quite normal growth till 30th October. Of course, they had to be protected from frost in that period. On 1st November all the plants were put to chilling effect as by this date the temperature of Murree falls down to frost level. The plants showed different degrees of resistance and susceptibility as follows:—

(1) Plants totally escaped the injury of frost.

(2) The leaves were only partially affected.

(3) All the leaves died away but the stem was least injured.

(4) Plants did not stand the effect of frost and died away immediately.

On 1st December all the plants were shifted to Samli to see how far each plant recouped from chilling injury and to get the maximum number of tubers per plant. It was observed that:—

(1) Varieties of S. tuberosum did not stand the effect of frost and dried up immediately.

(2) Most of the plants raised from S. commersonii, S. andigenum and S. acaule escaped the injury of frost.

(3) A good percentage of plants from the progenies of the crosses in which S. commersonii, S. andigenum and S. demissum were used in one way or the other escaped the injury of frost.

(4) S. acaule was not found to be transmitting its frost resistance character to its progenies.

Drought Resistance

The experiment was conducted through different intervals of irrigations, *i.e.* 7 days, 14 days and 21 days at the Vegetable Research Farm, Sargodha in the year 1958.

The crop was sown on 20th January and the first irrigation applied at the time of sowing was 3 inches. It was followed by a weekly irrigation of 2 inches intensity. After 28 days of the sowing of the crop, treatments included irrigation after 7 days, 14 days and 21 days. The crop was given a duration of 100 days in each treatment. It was observed that:—

(1) Application of more number of irrigations increased the yield and number of tubers per plant in all the varieties of S. tuberosum.

(2) The different intervals of irrigation did not have much effect on the height of plant, weight of plant and number of leaves in S. commersonii, S. andigenum and their selected crosses.

(3) The decrease in yield and number of tubers per plant was non-significant in wild species and their selected crosses.

Heat Resistance

The variations as brought about by heat and long photoperiodism are such that plants apparently looking more healthy and vigorous will give poor yield of tubers. The effect of heat on varieties of S. tuberosum, S. commersonii, S. andigenum and their selected crosses was also determined at Sargodha the same year by three different

dates of sowing *viz.*, 20th January, 5th February and 20th February. The crop was irrigated after every week and the growing period was 100 days. It was found that:—

(1) The dates of sowings had profound effect on the weight of plant, height of plant and number of leaves in all the varieties of S. tuberosum.

(2) The number of tubers in the first and second date of sowing showed significant increase over the number of tubers produced in the third date of sowing.

(3) The decrease in yield was nominal and non-significant in wild species and their selected crosses.

The authors are highly indebted to Mr. Abdur Rashid Khan, Vegetable Botanist, Lyallpur. The entire work was taken up under his guidance and supervision.

NOTICE

IT is notified that the offices of the West Pakistan Co-operative Fruit Development Board, Limited, have been shifted from the premises of the West Pakistan Agricultural University, Lyallpur to the Agricultural Research Institute, Risalewala-12, Jhang Road, Lyallpur. All the members may note the change.

Honorary Secretary.

QUALITY VEGETABLE SEEDS

By

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AND

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The seed is the basis of the crop that eventually is to be harvested. Within the seed may be locked up the key to future success or failure. Good seed is essential to success in Vegetable growing. The most careful and intelligent grower cannot achieve success with poor seed even he gives the closest attention. The yield and quality of vegetables depend mainly on the kind of seed used. The cost of seed forms only a small fraction of the total cost of production in vegetables but if the seed used happens to be a bad one, the return from the crop is greatly reduced and it often results in loss to the grower. It is, therefore, extremely essential that good quality seed should be used. Good seed should be clean, disease free, viable and true to name.

(*i*) *Clean seed.*—Good seed should not contain weed seeds and foreign matter. With proper care and removal of weeds while the crop is being grown, there is a little danger of vegetable seeds, containing many weed seeds.

(*ii*) *Disease free.*—Good seed should be free from diseases and insect injury. Some diseases are carried on seed coat while others are carried within the seed. If in doubt as to the freedom from disease, the grower may well treat his seed for the particular diseases likely to be present. Some seed borne diseases are effectively controlled by soaking the seed in hot water at 122°F for 20-30 minutes depending on the type of seed. This treatment kills the organisms causing alternaria, leaf-spot of crucifers and anthracnose of tomato and peppers. Hot water treated seeds should also be treated with some fungicide before planting to protect the seed from damping off and red rots which may be present in the soil.

(*iii*) *Viable.*—Good seed should be viable. Different kinds of seeds vary in the number of years during which they will give satisfactory germination. Figures for the longevity of different vegetable seeds vary considerably. Length of time the seed may be expected to retain their viability when stored in cool and dry rooms, is given below:—

Name of crop		Years
1. Beans	...	3
2. Beet root	...	4
3. Cabbage	...	5
4. Carrot	...	3
5. Cauliflower	...	5
6. Cucumber	...	5
7. Lettuce	...	5
8. Lady's finger	...	2
9. Muskmelon	...	5
10. Onion	...	1
11. Peas	...	2
12. Pepper	...	4
13. Pumpkin	...	5
14. Radish	...	5
15. Spinach	...	5
16. Squash	...	5
17. Tomato	...	5
18. Turnips	...	5
19. Watermelon	...	5

Seeds that are to be stored must be reduced in moisture content as much as possible by drying in a shallow layer in the sun. Then they should be sealed in a container and placed in as cool a place as is available.

Satisfactory germination is assumed to be such as to provide adequate stand of vigorous seedlings with a normal rate of seeding.

If the germination percentage is known, it is possible to increase the seed rate and get a favourable stand in spite of low germination. The proper temperature for germination test is from 50-60°F for winter vegetable seeds and from 60-70°F for summer vegetable seeds.

True to name

Good seed should be true to name and the variety. When the grower buys the seed, he does so with the expectation that it is a variety which he specially desires. The reliability of the seed firm is the best guarantee that the seed is clean, free from diseases, viable and true to type.

Reference

Vegetable Growing by James E. Knott.

LIST OF SPECIAL PRIZES FOR FRUIT PRODUCTS

1.	M/S Standard Fruit Products, Lyp. (Apple Preserve)	Rs. 10/-
2.	M/S Sunshine Fruit Products, Lyp. (Amla Preserve)	Rs. 10/-
3.	Village Aid Training Institute, Lyp. (Orange Squash)	Rs. 10/-
4.	Hafiz Shah Guldad Malakand Agency (Orange and Lemon Squash).	Rs. 10/-
5.	M/S Amir Ali Anwar Ali, Lahore. (Ginger Candy)	Rs. 10/-
	Grand Total	Rs. 50/-

ANNUAL PROVINCIAL FRUIT, VEGETABLE AND HONEY SHOW 1961

By

DR. SAEED AHMAD AND WASEEM AHMAD

Fruit Section, Lyallpur.

The 6th Annual Provincial Fruit, Vegetable and Honey Show was held at Lyallpur instead of Lahore so as to synchronize with the Golden Jubilee of the Punjab Agricultural College, Lyallpur. The dates were fixed from 30th December, 1960 to 3rd January, 1961. The show was a unique success. The exhibitors from all corners of the province took part in the show and exhibited their best Fruit, Fruit Products, Vegetables, and Honey.

A wide publicity was given to this event through radio, newspapers, posters and departmental circular letters. Moreover, the Railway authorities gave concession on the exhibits in booking, while Lyallpur Municipal Committee allowed the exhibitors of this show to cross the octroi-barrier free of charge.

A total number of 1762 entries were received in the show out of which 672 entries were that of fruit and 300 entries were of fruit products. The detail of the entries under different heads is given as under:

(*i*) Fresh Fruit, 672.

(*ii*) Fruit and Vegetable Products, 300.

(*iii*) Vegetables, 345.

(*iv*) Honey, 45.

The entries were made on 30th and the exhibits and stalls were arranged on 31st December, 1960.

On 1st January, 1961 technical staff, local officers and notables attending the Golden Jubilee gathered in groups for judging the exhibits.

In the morning of 2nd January, Lt.-General K. M. Sheikh, Minister for Food and Agriculture and Rehabilitation, Government of Pakistan cut the tape and declared the show open to public. After this he inspected the whole show.

On 3rd January, 1961 the show was graced by Nawab Malik Muhammad Amir Khan, Governor of West Pakistan.

Mr. S. I. Haq, C.S.P., Additional Chief Secretary, Government of West Pakistan (Planning and Development) very kindly gave away the prizes.

Before prize distribution, Khan Fazl-ur-Rahim Khan, Director of Agriculture, West Pakistan read a brief note pertaining to Departmental activities aimed at to promote fruit, vegetables and honey industry of the province. In reply to this, Mr. S. I. Haq, exhorted the work done by the Agriculture Department to promote fruit industry, truck farming and apiculture. More than Rs. 6000/- were distributed as cash prizes. Besides Governor's Shield, Challenge cups and one Honey-bee-comb were awarded by him.

In the fruit show the leading stalls were that of M/S Mitchell's Fruit Farms Ltd., Renala Khurd District, Montgomery, Fruit Development Board Garden, Mian Channu, Hilal Bagh, Kamalia, M/S Sh. Amir Ali, Anwar Ali, Lahore, M/S S. A. Rahman & Sons, Lahore, Kashmir Fruit Products, Lyallpur.

In addition to this Fruit Section at Agricultural College, Lyallpur Government Fruit Garden, Mirpur Khas and Tarnab Farms have also arranged very beautiful stalls, in which a number of good varieties of mandarin (sangtra), sweet orange (Malta) Bananas root stocks, avocado and fruit and vegetable products were displayed.

The following exhibitors were distinct by winning comparatively more number of prizes in the show.

FRESH FRUITS

1. M/S Mitchell's Fruit Farm, Renala Khurd, Montgomery.
2. Mian Allah Bux, Chak No. 671, Pirmahal, Lyallpur.
3. Ghulam Ahmad, Ata Muhammad Estate, Tharparkar.
4. West Pakistan Cooperative Fruit Development Board Ltd., Lyallpur.
5. Amir Habib Ullah Khan Saadi, Hilal Bagh, Kamalia, Lyallpur.
6. Mehdi Zaman Khan Kalabat, Hazara.
7. Mian Ahmad Shah of Ziarat Kallu Sahib, Peshawar.
8. Kaisar Khan Rajpar, Mirpur Khas.
9. Syed Jaman Shah of Mirpur Khas.
10. Noor Dad, Sawal Dhair, Mardan.

FRUIT PRODUCTS

1. M/S. Mitchell's Fruit Farm, Renala Khurd, Montgomery.
2. M/S. S. A. Rehman & Sons, Lahore.
3. M/S. Kashmir Fruit Products, Lyallpur.
4. M/S. Sh. Amir Ali, Anwar Ali, Lahore.
5. M/S. S. A. Rahim & Co., Lahore.
6. M/S. Anwar Fruit Products, Gujranwala.

LIST OF PRIZE-WINNERS FOR FRESH FRUITS

Amir Habib-Ullah Saadi, Hilal Bagh Kamalia, Lyallpur.

1.	Best Display of Fruits Big Garden	... ...	II Prize	Rs. 20/-
2.	Lemon	... ...	I Prize	Rs. 30/-
3.	Sweet Lime	... ...	I Prize	Rs. 30/-
4.	Sangtra Common	... ...	I Prize	Rs. 30/-
5.	Feutell's Early	... ...	I Prize	Rs. 30/-
6.	Sangtra (other special varieties)	... ...	II Prize	Rs. 20/-
7.	Miscellaneous Fruit	... ...	II Prize	Rs. 20/-

Mian Allah Bakhsh, Chak 671/G. B. Pir Mahal, Lyallpur.

1.	Malta Valencialate	... ...	I Prize	Rs. 15/-
2.	Sangtra (other special varieties)	... ...	I Prize	Rs. 30/-
3.	Musambi	... ...	I Prize	Rs. 30/-
4.	Apple and Guava	... ...	II Prize	Rs. 20/-

Mitchell's Fruit Farm, Renala Khurd, Montgomery.

1.	Best Display of Fruit Big Garden with Challenge Cup	.. ...	I Prize	Rs. 30/-
2.	Washington Navel	... ...	I Prize	Rs. 30/-
3.	Malta Valencialate	... ...	II Prize	Rs. 10/-
4.	Kinnow	... ...	II Prize	Rs. 20/-
5.	Lemon	... ...	Special Prize	Rs. 10/-

Mian Ahmad Shah of Ziarat, Kaka Sahib, Peshawar.

1.	Sweet Lime	... ...	II Prize	Rs. 20/-
2.	Malta other special varieties	... ...	II Prize	Rs. 20/-
3.	Grape Fruit Marsh Seedless	... ...	II Prize	Rs. 20/-
4.	Sangtra	... ...	Special Prize	Rs. 10/-

West Pakistan Fruit Development Board, Lyallpur.

1.	Best Display of Fruit Small Garden	...	I Prize	Rs. 30/-
2.	Grape Fruit (other varieties)	... ...	I Prize	Rs. 30/-
3.	Musambi	... ...	II Prize	Rs. 20/-
4.	Malta Valencialate	... ...	Special Prize	Rs. 10/-
5.	Malta Jaffa	... ...	Special Prize	Rs. 10/-

Ghulam Ahmad Ata Muhammadabad Estate, Tharparker.

1.	Banana Local	... ...	II Prize	Rs. 20/-
2.	Banana Harichall	... ...	II Prize	Rs. 20/-

Mehdi Zaman of Kalabat, Hazara.

1.	Malta (other special varieties)	... ...	I Prize	Rs. 30/-
2.	Malta Blood Red	... ...	II Prize	Rs. 20/-
3.	Malta Sacrey	... ...	Special Prize	Rs. 10/-
4.	Washington Navel	... ...	Special Prize	Rs. 10/-

Faiz-i-Am Nursery, Multan.

1.	Dates	...	... II Prize	Rs. 20/-
2.	Apple and Guava	...	... II Prize	Rs. 20/-

Kaisar Khan Rajar, Mirpurkhas.

1.	Banana Harichall	...	... I Prize	Rs. 30/-
2.	Miscellaneous Fruit	...	... II Prize	Rs. 20/-

Syed Jawan Shah of Mirpurkhas.

1.	Banana Harichall	...	... II Prize	Rs. 20/-
2.	Miscellaneous Fruit	...	... I Prize	Rs. 30/-

Ghulam Bari Zia, Chak 393/J. B. Teh. T. T. Singh, Lyallpur.

1.	Malta Valencialate	...	... I Prize	Rs. 15/-

Waris Khan of Haripur Hazara.

1.	Banana Local	...	... I Prize	Rs. 30/-

Sher Ali Khan of Tangi, Charsada, Peshawar.

1.	Malta Ruby Red	...	... I Prize	Rs. 30/-

Sher Muhammad Khan of Sherpur, Charsada, Peshawar.

1.	Malta Blood Red	...	... I Prize	Rs. 30/-

Abid of D. I. Khan.

1.	Dates	...	... I Prize	Rs. 30/-

Ghulam Nabi, Mustung, Kalat.

1.	Dried Fruit	...	... I Prize	Rs. 30/-

Masoom Shah, Kagan Valley, Hazara.

1.	Dried Fruit	...	... I Prize	Rs. 30/-

Ahmad Rahman Baluch of Hira Abad, Hyderabad.

1.	Banana Harichhall	...	... I Prize	Rs. 30/-

Ch. Niaz Ali Khan Sahib, Nathu Chak No. Lyallpur.

1.	Malta (other special varieties)	...	... I Prize	Rs. 30/-

Malik Muhammad Afzal of Hana, Quetta.

1.	Apple and Guava	...	... I Prize	Rs. 30/-
2.	Apple	...	... Special Prize	Rs. 10/-

Founder of Swat State, Swat.

1.	Apple and Guava	...	... I Prize	Rs. 30/-

Muqarrab Khan of Hyderabad, Mardan.

1.	Grape Fruit (March Seedless)	...	... I Prize	Rs. 30/-

Sh. Muhammad Sharif, Development Officer, Azad Kashmir.

1.	Dried Fruit	...	... II Prize	Rs. 20/-

Soab of D. I. Khan.

1. Grape Fruit (other varieties) ... ... II Prize Rs. 20/-

Raja Garden and Nursery Chak 288/T. T. Singh, Lyallpur.

1. Malta Valencialate ... ... II Prize Rs. 10/-
2. Malta Blood Red ... ... Special Price Rs. 10/-

Mian Ihsan-ul-Haq, Gokhuwal, Chak 121/J. B. Lyallpur.

1. Sangtra Lemon ... ... II Prize Rs. 20/-
2. Guava ... .. Special Prize Rs. 10/-

Jehanzeb of Nawan Kali, Mardan.

1. Washington Navel ... ... II Prize Rs. 20/-

Raja Muhammad Aslam Khan of Nikrian, Hazara.

1. Malta Ruby ... ... II Prize Rs. 20/-

Ahmad Khan of Turbandi, Mardan.

1. Lemon ... ... II Prize Rs. 20/-

Muhammad Sharif Chak 166 R.B. Sheikhupura.

1. Malta (other special varieties) ... ... II Prize Rs. 20/-

Abdul Hadi Khan of Gulistan, Quetta.

1. Dried Fruit ... ... II Prize Rs. 20/-

Shaukat Ali, Nawan Pind Gujran, Lahore.

1. Feutrell's Early ... ... II Prize Rs. 20/-

Noor Dad of Swaldher, Mardan.

1. Miscellaneous Fruit ... ... I Prize Rs. 30/-

Qutab Garden Chak 9/J. B. Lyallpur.

1. Kinnow ... ... I Prize Rs. 30/-

Mian Iftkhar-ud-Din, Jalalpur, Lahore.

1. Kinnow ... ... I Prize Rs. 30/-

Mian Noor Ahmad, Baghbanpura, Lahore.

1. Kinnow ... ... II Prize Rs. 20/-

Mian Muhammad Hayat, Karhail Wala.

1. Best display of fruits ... ... Special Prize Rs. 20/-
2. Feutrell's Early ... ... Special Prize Rs. 10/-

Bahadur Sher of Ghoriwala, Bannu.

1. Miscellaneous Fruit ... ... Special Prize Rs. 10/-

Rehmat Shah of Swaldher, Mardan.

1. Malta Ruby Red ... .. Special Prize Rs. 10/-

Ch. Allah Ditta Khan Chak No. 28 I.A.L. Montgomery.

1. Miscellaneous Fruit ... ... Special Prize Rs. 10/-

Abdul Qayum Khan, District Kalat.

1. Apple ... ... Special Prize Rs. 10/-

Muhammad Umar Khan of Topi, District Mardan.

1. Ruby Red ... ... Special Prize Rs. 10/-

Firdaus Khan of Ghar Bagh.

1. Ruby Red ... ... Special Prize Rs. 10/-

Umar Ali of Kalabat.

1. Ruby Red ... ... Special Prize Rs. 10/-

Sher Akbar Spenhi.

1. Washington Navel ... ... Special Prize Rs. 10/-

Haji Amir Ullah Khan of Toru.

1. Malta Musambi ... ... Special Prize Rs. 10/-

Shah Pasand Khan of Charguli.

1. Sweet Lime ... ... Special Prize Rs. 10/-

Ali Haider Shah of Ismaila.

1. Ruby Red ... ... Special Prize Rs. 10/-

Rehmat Shah of Saval Dher.

1. Malta Valencialate ... ... Special Prize Rs. 10/-

Nawab Zada Saadat Ullah Khan.

1. Malta Temple ... ... Special Prize Rs. 10/-

Arbab Noor Mohd Khan of Peshawar.

1. Grape Fruit ... ... Special Prize Rs. 10/-

Haji Safdar Khan of Charsadda.

1. Persimmon ... ... Special Prize Rs. 10/-

Munawar Khan of Abad Khel, Bannu.

1. Guava ... ... Special Prize Rs. 10/-

Mian Feroze Shah of Nowshera.

1. Musambi ... ... Special Prize Rs. 10/-

Faizullah Khan of Chandu Khel, District Bannu.

1. Malta Blood Red ... ... Special Prize Rs. 10/-

Dur Muhammad of Panyala District D. I. Khan.

1. Dates ... ... Special Prize Rs. 10/-

Ishaq Hussain, Khuram Agency.

1. Walnuts ... Special Prize Rs. 10/-

Khail Muhammad of Khuram Agency.

1. Malta Walnuts ... ... Special Prize Rs. 10/-

Rana Hidayat Muhammad District Saradha.

1. Ruby Red ... ... Special Prize Rs. 10/-
2. Musambi ... ... Special Prize Rs. 10/-
3. Kinnow ... ... Special Prize Rs. 10/-

Ch. Jumma Khan of Chak No. 217/R. B. Lyallpur.

1. Kinnow ... ... Special Prize Rs. 10/-

Punjab Nurseries, Lyallpur.

1. Feutrells Early ... ... Special Prize Rs. 10/-

LIST OF PRIZE WINNERS IN FRUIT PRODUCTS (Commercial).

M/S Mitchell's Fruit Farms, Renala Khurd.

1.	Golden Mist	I Prize	Rs. 30/-
2.	Lemon Squash	I Prize	Rs. 30/-
3.	Tipari Jam	I Prize	Rs. 30/-
4.	Tomato Juice	I Prize	Rs. 15/-
5.	Tipari Syrup	I Prize	Rs. 25/-
6.	Canned Peas	I Prize	Rs. 20/-
7.	Guava Jelly	II Prize	Rs. 20/-
		Total	Rs. 170/-

M/S S. A. Rahman & Sons.

1.	Best Display of Fruit Products	II Prize	Rs. 20/-
2.	Guava Cheese	II Prize	Rs. 20/-
3.	Amla Preserve	II Prize	Rs. 20/-
4.	Tomato Ketchup	II Prize	Rs. 10/-
5.	Malt Vinegar	II Prize	Rs. 15/-
6.	Mango Chutney	II Prize	Rs. 15/-
7.	Mango in Syrup	II Prize	Rs. 15/-
		Total	Rs. 115/-

M/S Kashmir Fruit Products, Lyallpur.

1.	Best Display of Fruit Products with Challenge Cup		Rs. 30/-
2.	Carrot Preserve	I Prize	Rs. 30/-
3.	Canned Guava	I Prize	Rs. 25/-
4.	Canned Grapes	II Prize	Rs. 15/-
5.	Orange Squash	II Prize	Rs. 20/-
		Total	Rs. 120/-

M/S Amir Ali Anwar Ali, Lahore.

1.	Lemon Pickle	I Prize	Rs. 20/-
2.	Lemon Syrup	II Prize	Rs. 20/-
3.	Carrot Candy	II Prize	Rs. 20/-
		Total	Rs. 60/-

S. A. Rahim & Co., Lahore.

1.	Cherry Candy	I Prize	Rs. 30/-
2.	Mixed Pickle	II Prize	Rs. 15/-
		Total	Rs. 45/-

Anwar Fruit Products, Gujranwala.

1.	Syrup Rooh-e-Shabab	I Prize	Rs. 30/-
2.	Fruit Vinegar	I Prize	Rs. 20/-
		Total	Rs. 50/-

M/S Punjab Fruit Products, Lyallpur.

1.	Mango Chutney	I Prize	Rs. 20/-
		Grand Total	Rs. 580/-

N.B.—There was only one entry for canned vegetable in Part XI-48, therefore there was no competitor for II Prize Rs. 15/-.

LIST OF PRIZE WINNERS IN FRUIT PRODUCTS (Home Scale).

Ch. Muhammad Iqbal Mian Channu.

1.	Tomato Ketchup	I Prize	Rs. 15/-
2.	Dried Carrot	I Prize	Rs. 15/-
3.	Dried Mint	II Prize	Rs. 10/-
4.	Mango Pickle	II Prize	Rs. 15/-
		Total	Rs. 55/-

Mazhar Qayum IV Year Student, P. A. C. Lyallpur.

1.	Mango Pickle	I Prize	Rs. 20/-
2.	Apple Preserve	I Prize	Rs. 20/-
		Total	Rs. 40/-

Zulfiqar, Lyallpur.

1.	Mango Squash	I Prize	Rs. 20/-

Ahmad Din Punjab Agricultural College, Lyallpur.

1.	Orange Squash	II Prize	Rs. 15/-

Village Aid Trainees, Lyallpur.

1.	Carrot Preserve	II Prize	Rs. 15/-

Muhammad Hussain.

1.	Guava Cheese	I Prize	Rs. 20/-

Muhammad Jamil IV Year Student T. A. C. Lyallpur.

1.	Guava Jelly	II Prize	Rs. 10/-

Muhammad Aslam Riaz, Lyallpur.

1.	Tomato Ketchup	II Prize	Rs. 10/-
		Grand Total	Rs. 190/-

MITOSIS IN VICIA FABA ROOT TIP

By

MUHAMMAD YAQUB, M.Sc., Agri. (Pb.); M.Sc. Arizona Dip. (Wisconsin)

The mechanisms through which the regularities in chromosome complement are maintained is an important subject for a student of cytology. The problem has two facets. First, how is the regular diploid complement of chromosomes kept constant through the successive nuclear divisions involved in the growth and development of a multicellular individual from a single cell, the fertilized egg? And second, what special phenomena in germ-cell formation result in haploid gametes, each with one member of each pair of chromosomes, so that diploidy is restored at fertilization? The process responsible for the maintenance of the first of these two bases of regularity is ordinary somatic nuclear division, and is called mitosis.

An understanding of the mode of mitosis in Vicia faba may be of some interest to the research workers and the same is presented here.

REVIEW OF LITERATURE

Sharp (1943) has illustrated that in mitosis, each chromosome duplicates itself, the duplicates separate as the nucleus divides, so that the daughter nuclei are identical in chromosomal constitution. SRB and Owen (1957) have stated that the process of nuclear division is a continuous series of changes, only by arbitrary distinctions can we break up the process into 'stages' or 'phases' for separate consideration. According to Sharp (1943) a resting nucleus undergoes a continuous sequence of changes called prophase, metaphase, anaphase and telophase.

MATERIAL AND METHODS

The studies were carried out in a Laboratory of the Botany Department, University of Arizona, Tucson. The seed of Vicia faba was germinated in petri dishes and the roots obtained from them when they were about 3 mm. long. The slides were prepared and properly stained. The studies were made on a phase microscope of the Botany Department.

RESULTS AND DISCUSSION

As pointed out by Sharp (1943), the process of cell division were divided into various phases. In this case various stages of metaphase and anaphase have been studied. In this connection reference is invited to Fig. 1 and Fig. 2 for metaphase studies and Fig. 3 for the anaphase stage. The haploid number of the Vicia faba for these studies in 7 since we find 14 chromosomes going to the poles of the spindle separating at the spindle plate. These results are in conformity with those of Yarnell (1954), Myers (1947) and Hughes et al (1951).

A glance at Fig. 1 of the metaphase stage indicates that the chromosomes are splitting lengthwise so that the chromatids are easily visible. The centromeres are quite clear in most of the chromosomes. In this Fig. the chromosomes are just arranging to assemble on the spindle plate. One of the chromatids of chromosome 5 shows a secondary constriction while its sister chromatid does not indicate such a secondary constriction. Chromosome 6, 3 and 7 show heterochromatin regions. These are labelled at those places. In Fig. 2 the chromosomes have arranged themselves on the equatorial plate and they are at the verge of their separation from one another. From Fig. 3, it is clear that the chromosome numbers can be counted at the anaphase which is usually difficult in ordinary cases.

Some of the chromosomes, at any rate, are individually recognisable because of their size and shape (Sinnett et al 1951). In Indian corn (maize), each of the 10 pairs of chromosomes can be identified by its length relative to the other chromosomes in the same nucleus, by the location of centromere, and by 'Secondary' constrictions in the body of the chromosomes which make the latter resemble a series of beads. The relative length of the various pairs of chromosomes has been given in Fig. 4 and the different chromosomes have been symbolized by numbers, from chromosomes I (the longest) to chromosome 7 (the shortest)

as suggested by Longley (1941). The seven different chromosomes are distinguishable in terms of their length, the relative length of their arms (the centromeres shown as oval shaped). Clear heterochromatin zones were noticed. A common number for two particular chromosomes indicates that they are the homologues. The centromeres in some cases are quite clear while in the others they are not so conspicuous. Of course by studying the different stages these centromeres can be located.

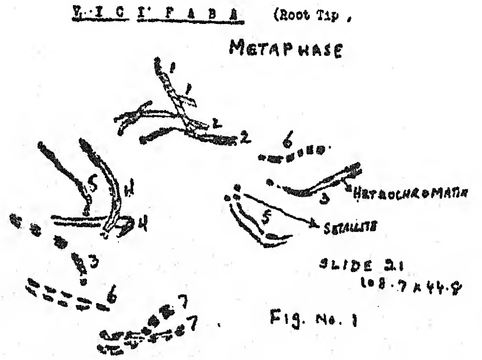

Fig. 1.—Metaphase in the root tip of Vicia faba The chromosomes are splitting lengthwise so that the chromatids are easily seen. The centromeres are quite clear in most of the chromosomes. They (chromosomes) are just arranging together on the spindle plate. One of the chromatids of chromosome 5 shows a secondary constriction while its sister chromatid does not do so. Chromosome 6, 3 and 7 shows heterom-chromatin regions.

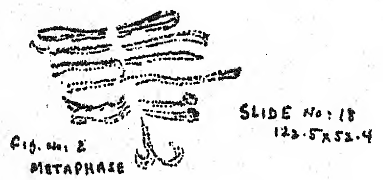

Fig. 2.—Metaphase in the root of Vicia faba. The chromosomes have arranged themselves on the equatorial plate and they are at the verge of their separation from one another.

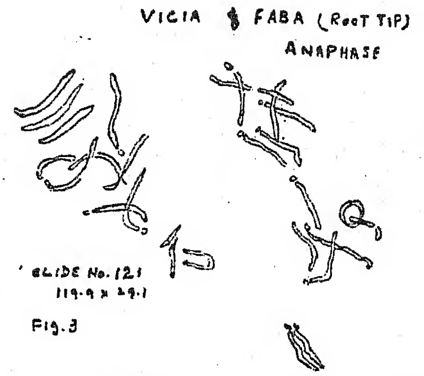

Fig. 3.—Anaphase in the root tip of Vicia faba. Usually it is difficult to count the exact number of chromosomes at this stage but in this figure, as observed on the slide the number can be easily counted. We can see the position of centromeres in some cases.

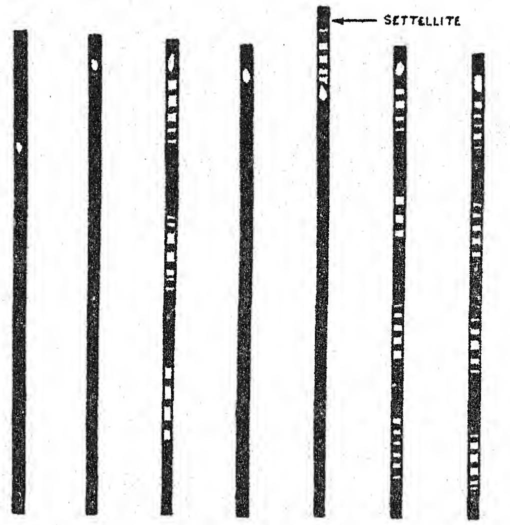

Fig. 4.—Representation of the chromosomes illustrating relative lengths, position of centromeres (clear, oval shaped), hetero-chromatin zones (dotted) and satellite or secondary constriction (oval shaped densely stained).

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COCONUT PALM CARE IN NURSERY AND FIELD

BY

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INTRODUCTION

In many lands the coconut provides much of the economy of the people. This includes food, fibre, building material, and copra for export.

East Pakistan produces Coconuts on about 39,300 acres and consumes about 80% of the nuts as fresh fruit and milk. Large amounts of oil and coconut products are imported annually.

There are vast areas of land in the coastal and Chittagong Hill Tracts where coconut growing appears to be the best possible use of the land.

The storm of October 31, 1960 proved the ability of the coconut tree to resist wind and the great waves of water and serve as a life saver for people, and has stimulated interest in increasing planting of coconuts in these areas where damage was so severe.

In East Pakistan, the coconut palms growing in the province are very valuable and deserve the best known care and protection against insects, disease and injuries. They need fertilizing, cultivating, replacing and most of all an increase in number. If yields per tree can be doubled, 100,000 acres may produce all the copra, coconut oil, fruit nuts and milk nuts needed. This is a very great challenge to the cultivators of East Pakistan.

What can be done to increase the production of the coconut and its products in East Pakistan?

1. Obtain the best possible seed and grow a nursery?
2. Grow more coconut palms?
3. Take better care of the coconut palms we have?
4. Replace poor producers?
5. Learn to make good copra?

These five efforts seem to be the best answers. Let us analyse each.

I. Obtain the Best Seed and Grow a Nursery

Your Government has started a vigorous program to help increase the production of coconuts. It consists of three parts. The organizing of a research program at Barisal. The lease of land for planting coconuts to private growers. The third part is the importation of 200,000 seed nuts from Ceylon with many more to come from Malaya and the South Pacific Islands.

These primary seeds should give East Pakistan the best coconut seed in the world. This is a good start. They represent the best source of seedlings available. Growers should obtain their seedlings from this source if at all possible.

Records should be accurately kept on all of these seedlings as they grow into producing trees and the best ones selected as seed producing trees, or *Mother* trees.

There are many excellent producing coconut trees in East Pakistan. A program of selecting and testing these trees as *Mother Trees* for producing seeds should be greatly expanded and hastened.

Selection of Mother Palms

Mother palms are the source of seed for planting. They should be the best and most productive trees in your Union area.

Mother palms should be selected from groups of trees where they produce in spite of competition and not because they are favored by space or other advantages.

A mother palm should have a history of producing over 100 dry nuts annually from which 60 pounds of copra can be produced. Copra will amount to about one third of the weight of the nut in the shell without the husk.

The nuts should be medium to large size and round nuts are preferred.

The tree should have a graceful symmetrical appearance with leaves well arranged not severely upright and not excessively drooping.

Mark each Mother Palm tree with a broad easily recognized band and give the tree a number.

Develop a system of monthly harvesting and recording of the nuts from each mother palm and develop a mother palm testing program in your Union Agricultural Extension Service. Some seedlings from each mother tree must be certified as to their productivity for twenty-five years or more to be of most value.

How to Make a Nursery

Location.—Select a sandy loam soil of 18 inches in depth or more with good subdrainage and free from floods. The place must not be in the shade of trees or buildings but should be near a supply of water for irrigation. The nursery must be fenced and well protected from damage by livestock. Dig the soil to a depth of twelve inches. Prepare the bed 10 inches above the ground level, six feet wide and as long as is convenient to irrigate. Provide surface drainage ditches necessary to take care of all the surplus water quickly.

No cow dung or organic matter is used for fear of encouraging the attack of white ants. Chemical soil treatments need to be tried to meet this problem. (*See* Notes Nos. 1 and 4.)

Get seed for your private nursery, or planting in place, from the best producing tree in your area. Don't just plant any seedling. Get your seed from trees that produce over 100 good shaped large ripe nuts a year.

Seeds are selected with great care for desirable characters associated with high yields of copra and growth of strong seedlings. The seed must have a good supply of milk water in order to germinate and make a good healthy growth.

Furrows are made 18 inches apart and the holes for the nuts are dug just deep enough to bury the nut leaving a small part, about one inch of the top exposed. The nut is placed with the stem end (end with the eyes) facing the East and at about two inches higher level than the blossom end of the nut. The largest flat side is placed downward. The nuts are placed on 18 inches centres in the row. This allows about 12 inches from nut to nut.

Moisture and sunshine are the important elements in the successful coconut nursery as most of the growth is made from the plant nutrients stored in the nut. A thorough irrigation once a week between the rows of seed nuts may meet the moisture needs but moisture must be checked frequently and applied when needed.

In six months of good growing conditions the coconut seedlings will have developed three standard type leaves and height of about three feet. They are ready for transplanting to their permanent location.

Great care in digging and handling must be taken to avoid breaking the new growth form the nut or otherwise injuring the plant.

A kodal is used to raise the rooted nut. Don't pull by the stem. The kodal is sunk deeply at one side and under the young plant without injury to the old seed nut shell. The plant is pushed out of the soil from below.

Lift the nut carefully from the soil by pressure on the under side of the nut with both hands. Handle with care at all times.

Success depends upon getting these young plants quickly palnted in their permanent location without drying out or exposure to the sun.

Be sure the holes are all prepared, dirt refilled and settled before you dig the seedlings for moving.

Be sure to use only the healthy fast growing, strong dark green plants. Throw away the weak ones. Only the best are to be kept for seventy-five years of cropping.

Avoid crushing the growing parts of the young coconut seedlings. Never stack more than two deep and pack so as to avoid injury.

II. Plant More Coconut Palms

There is always a place to plant one more coconut palm, in an unused corner, along a roadway or on a reservoir bank. Tables of earth can be built up four feet above the high water level and not less than ten feet wide. The low lands can be drained in this manner as is done in the Philippines. Plant a portion of your best sandy loam land to coconuts. Each cultivator will find his answer by his study of his own farm. People living in the villages and towns should also want to join the planting program. 32,500 more acres are needed now.

Location.—The coconut will grow and produce best in a deep well subdrained sandy loam, free from long periods of flood waters and free from high levels of salt. It will grow and make an effort at production in spite of some imperfections of soil and location. It will withstand some saline soil condition but does not prefer this condition. Experience of growers in the area can be a helpful guide. The coconut tree will stand where you put it and produce crops for seventy-five years. Give it a good place to work four feet above the high water level.

Land Preparation.—Coconut planted twenty-eight feet apart will require 55 plants an acre. Square plantings with trees in line are more satisfactory than in triangles when they are inter-cropped.

Prepare all of the land as though a field crop is to be planted.

Dig large holes 3′×3′ square and three feet deep.

If practical, discard the subsoil and use surface soil in preparing a mixture with 5 pounds bone meal and five pounds oil cake to refill the hole. Thoroughly rotted cow-dung and compost is helpful if the cultivator is prepared and knows how to control the attacks of white ant. Settle the soil in the hole with water. Postpone planting until the planting condition of soil is correct (not too wet). (*See* Note No. 2.)

¼ ounce of Sulphate of Ammonia may be used, or ½ this amount Urea, scattered over the entire area of the hole, but avoiding the area within one foot of the tree. This may be applied every two months if yellow color and slow growth indicates the need. (*See* Note No. 3.)

Fertilize the young plant after the first year with ½ lb. Sulphate of Ammonia, ½ lb. murate of potash, and ½ lb. triple super phosphate per year. Double these amounts in the 3rd and 4th year.

III. Take Better Care of the Trees We Have

1. Eliminate the competition of non-producing trees, shrubs and weeds. Shade trees are of little value. Give each tree plenty of room for its roots and sunshine for its top. 28 feet in each direction is a good planting distance. (*See* Picture No. 9). Shade trees do have a value if in the right location but they do compete or take the place of a fruit or nut tree.

2. *Cultivation.*—All the ground should be cultivated but not deep enough to injure roots. This helps to work organic matter such as cow dung into the surface soil, and eliminate weed competition.

3. *Fertilize Coconut Trees.*—Four pounds of Sulphate of Ammonia per tree per annum for palms over five years of age is suggested when all other growing conditions are favorable. Two applications are preferred, one after the first rains in May and the second before the last rains of September. If Urea is substituted for Sulphate of Ammonia use one half as much but divide into four applications. Urea is much more leachable than Sulphate of Ammonia. Apply the fertilizer to the entire root growing area. Avoid the area within two feet of the tree trunk.

Two pounds of Triple super phosphate per tree or five pounds of bone meal is suggested for each tree worked into the surface soil over the area of greatest root concentration.

Two pounds of murate of potash per tree is also suggested as a standard per acre. Cow dung, compost, all forms of decaying plant material, coconut husks, leaves, etc.

should be returned to the soil to aid in maintaining its favorable structure and fertility. 200/300 maunds of cow dung an acre annually is suggested.

4. *Protection.*—Protect young trees from livestock. Protect all trees from insect, and diseases injury.

Make three regular inspections each year for the Oryctes rhinoceros beetle. Learn the wire method of control. Predators and parasites are a hope for future control that should be constantly studied by the coconut research staff. (*See* Note No. 5.)

This beetle is extremely serious in the Cox's Bazar area and is a factor of damage to many palms in all parts of the Province. Leaves damaged before emerging, appears to have been cut off by scissors and the injury can be recognized as far as one can see the tree. Learn about control through the use of manure traps. (*See* Picture No. 14, Note No. 5.)

Cadang.—Cadang disease has killed thousands of acres of coconut palms in some area of the Philippines. The greatest of caution should be taken to avoid bringing this disease to East Pakistan.

5. *Irrigation.*—Adequate moisture is essential for heavy production of nuts. Study the need and possible supply of water during the winter months in the dry areas such as Jessore and Kushtia. One or two heavy irrigations supplementing rainfall may prove to be an excellent investment. A year of drought will decrease two years of crops.

IV. Replace Poor Producers

Some coconut trees are known to have produced small crops in comparison to other trees in the same environment. If the tree does not respond to improved care by producing satisfactory crops a new tree replacement should be started. This can be done several years before removing the old tree if it has some productive value or can be a direct replacement as described under "Land Preparation".

V. Learn to make good Copra

An information circular is being prepared on this subject.

Note No. 1

In other area it is suggested to mix the loosened soil with large amounts of rotten leaves, composted material and ash from burnt fresh coconut husks at the rate of 25 pounds to 225 square feet of Nursery. White ants become a problem if this is done in this area without adequate control measures.

Note No. 2

W. V. D. Pieris in "Wealth from the Coconut" suggested placing two layers of coconut husks without shells, at the bottom of the hole. Then, fill it up to within six inches of the ground level with top soil mixed with dry leaves, leaf-mold and other decayed vegetables matter, and add four pounds of burnt fresh coconut husks or add 2 pounds of murate of potash which was considered better than the husk ash. This was to be settled by trampling down and by watering and then adding top soil to bring the level within six inches of the soil level.

The danger of damage by white ants prevents this recommendation being made for use in this area.

Note No. 3

¼ ounce every two months on 9 square feet or for the approximate area covered is at the equivalent rate of 454 pounds of Sulphate of Ammonia to an acre per annum. It seems so small an amount that there is danger of using more to the point of being harmful.

Note No. 4

Where termites or white ants cause serious damage, India reports the use of 1 pound of 50% B.H.C. in 50 gallons of water. Use enough to soak the soil several inches deep around the infested plant.

Note No. 5

Rhinoceros Beetle on Coconut Palm.—The mature Rhinoceros beetle flies to the crowns of coconut palms where it bores into the tender new growth in order to feed on the plant juice.

Rhinoceros attack coconut palms of all ages. The damage may stunt the growth, decrease future yield of nut or kill the palm. Leaves, as they grow out, may show damaged areas giving the palm a ragged appearance.

Deep notches are seen in the sides of the damaged palm trunks years after the injury has been made. The mature Rhinoceros beetles are present throughout the coconut areas of East Pakistan. They are present in most parts of the world where cocconuts are grown. The adult is large, two inches or over in length and an inch wide with a characteristic horn on its head from which it gets common name and uses for tearing into the young tender tissue of the palms.

The black beetle does not breed in healthy palm tree tissue but prefers manure piles, decaying organic matter, dead and rotting coconut palms and other trees.

Eggs are laid by the adult Beetle searching out these favorable incubation places. The small white eggs hatch in 10 to 20 days into grubs which may require from three to eight months depending upon temperatures. The pupae stage may take from 2 to 9 weeks.

The adult beetle emerges and may attack any one of many host plants including the Beetle Nut Palm.

Manure Trap Control Method

Six or more manure traps on each acre which are consistently kept in good moist condition for beetle egg deposit and sprayed at a regular interval with dieldrin appears to be a practical control program. Each Manure pile traps is protected by a small bamboo top.

Collection of beetles from Crowns

Learn and make use of inspection and wire control method. First clean up all breeding places by disposing of untreated manure piles, rotting trees—and by preventing breeding places in damaged palms.

Injured trees should be treated with tar to prevent attack by Red weevel grubs which will be followed by rhinoceros beetle egg deposits and grub development.

Area Beetle Control

Rhinoceros beetle control success depends upon a community wide program of control. All Manure should be spread thinly on the land. All rotting organic matter should be frequently inspected and disposed of before grubs develop into pupae and adults.

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Note No. 6

An Indian circular on Coconut Care suggested a fertilizer program as follows where soils were not deficient in organic matter.

	per tree per year
Ammonium sulphate ...	4 lbs
Muriate of potash or Sulphate of potash ...	2 lbs.
Bone meal or super phosphate ...	2 lbs.
or	
Ground Oil Cake ...	15 lbs.
Ash ...	20-40 lbs.

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KARYOTYPE ANALYSIS AND POLYPLOIDY IN ONION ROOT TIP

By

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Two processes govern and insure the continuation of species from one generation to the next. In broader sense, these are the union of cells and the division of the cells. The latter process is the characteristic of all cellular organisms, while the former is found in those organisms that produce sexual cells, or gametes.

A detailed knowledge of these processes is a necessary pre-requisite to an understanding of heredity. This paper deals with the study of karyotype analysis of root tips of onion conducted at the University of Arizona, Tucson, U.S.A. under the guidance of Dr. Harris of the Botany Department.

REVIEW OF LITERATURE

Cell nuclei were first seen and named by Robert Brown in 1831, but their biological significance become apparent only when Strasburger (1875), Butschli (1876), and other discovered that nuclei arise exclusively from other nuclei by means of remarkable process of division which Fleming (1882) called mitosis.

Chromosomes numbers have been determined for many crop plants by Myers (1947), Hughes et al (1951), Yarnell (1954) Darlington (1955), (1937), Makino (1951). According to Year Books of the U.S.A. Department of Agriculture 1936 and 1937 the number of chromosomes in a diploid cell of onion has been indicated as sixteen. A study of chromosome numbers in related species of economic plants show many multiple series (Heyes et al 1955).

The chromosomes can be identified with regard to their relative lengths as indicated by Longley (1952), Wipf et al (1938); shape of the chromosomes, nucleolous forming regions, knob and constructions, presence of satellites and heterochromatin nature of chromosomes as pointed out by SRB and Owen (1957).

MATERIAL AND METHODS

Root tips of onion were obtained from the Horticulture Department of the University of Arizona, Tucson. The Cytological work was carried out in a Laboratory of the Botany Department. While staining the material, no iron acetate was added because too much iron precipitates the carmine. These studies were made on phase microscope of the Botany Department.

RESULTS AND DISCUSSION

For convenience sake, the processes of cell division have been divided into four stages : interphase, prophase, metaphase, anaphase and telophase. Although the various stages are readily identified by certain appearances or landmarks, cell division is a dynamic and continuous process, each step passing almost imperfectly into the next. Metaphase and anaphase stand out as the most sharply discontinuous stages and as a result are the most easily defined. The entire process may be separated into karyokinesis, or nuclear division, and cytokinesis, or cytoplasmic division. The term mitosis, which is synonymous with karyokinesis, has frequently been applied to cell division as a whole, but in the strict sense of its original meaning it should include only the division of the nucleus. I will describe only the important stages and defer the lesser important one.

At the beginning of the cell divisions mitosis, the mother nucleus resolves itself into a mass of coiled or twisted threads. Each thread is already split lengthwise into halves. These double threads are the

chromosomes and the each half is called the chromatid. This is the stage of prophase. The disappearance of the nuclear membrane usually brings prophase to an end. The spindle soon appears, and metaphase is initiated. It serves to bring the chromosomes into the metaphase, or equatorial plate, as the first step in the separation of daughter chromatids. In this connection reference is invited to fig. 1 *a*, *b* and *c* which indicate different stages from metaphase to anaphase. The haploid number of the onion root for these studied is 8 since we find 16 chromosomes going to the poles of the spindle separating at the spindle plate. These results are in conformity with those of Yarnell (1954), Myers (1947) and Hughes et al (1951).

Some of the chromosomes, at any rate, are individually recognisable because of their size and shape (Sinnett et al 1958). In Indian corn (maize), each of the 10 pairs of chromosomes can be identified by its length relative to the other chromosomes in the same nucleus, by the location of centromere, and by 'Secondary' constrictions in the body of the chromosomes which make the latter resemble a series of beads. The relative lengths of the various pairs of chromosomes has been given in fig. No. 3 and the different chromosomes have been symbolized by numbers, from chromosomes 1 (the longest) to chromosome 8 (the shortest) as suggested by Langley (1941). The eight different chromosomes are distinguishable in terms of their length, the relative length of their arms (the centromeres shown as oval-shaped). No heterochromatin zones were noticed. A common number for two particular chromosomes indicates that they are the homologues. The centromeres in some cases are quite clear while in the others they are not so conspicuous. Of course by studying the different stages these centromeres can be located.

In one instance it was observed that instead of 16 pairs there were found 32 pairs. This is presumably the result of two nuclei failing to separate, or at least failing to have a cell well formed between them after a division. Such accidents are not uncommon. The great constancy of nuclei and chromosomes in plants is due to the fact that anything different from the ordinary course usually fails to survive. If such irregularities survive, plants with new characteristics may come up and they may breed true for new characters. The cell observed is a tetraploid and the details regarding the 32 pairs (chromatids) are drawn in Fig. 2.

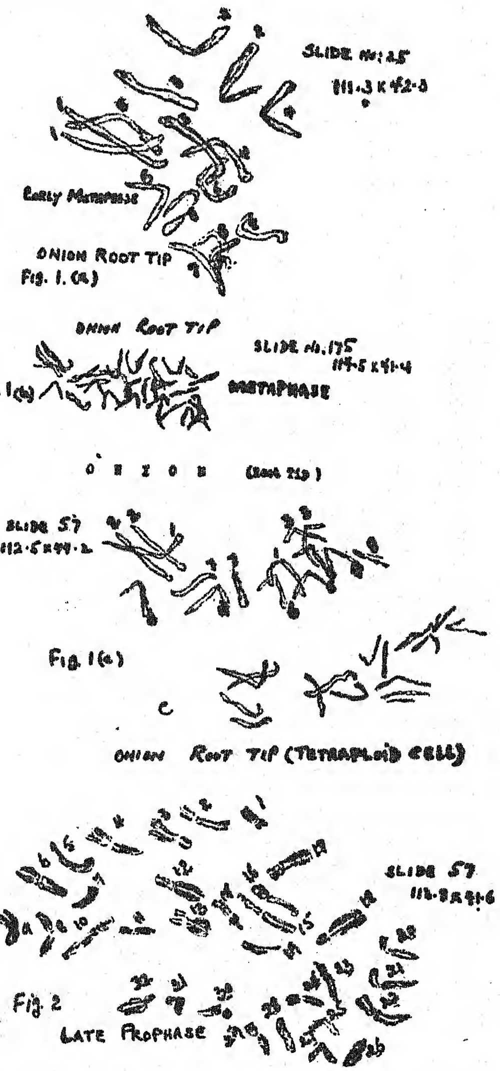

Fig. 1 (*a*). It is a stage of Early Metaphase of onion root tip. The chromosomes cannot be seen splitting lengthwise. The number of the chromosomes can however be counted quite easily and the position of the centromeres located in most of the cases.

Fig. 1 (*b*). Metaphase of the onion root tip. Chromosomes are arranging themselves on the equatorial plate. The number of the crhomosomes at this stage could not be counted.

Fig. 1 (*c*). Anaphase of the onion root tip cells. The slide from which this drawing has been taken gives an excellent shape and number of chromosomes. Besides showing the position of centromeres in most of the chromosomes we can observe their homologues. The homologues have been marked in the chromosomes going towards the upper pole of this figure spindle.

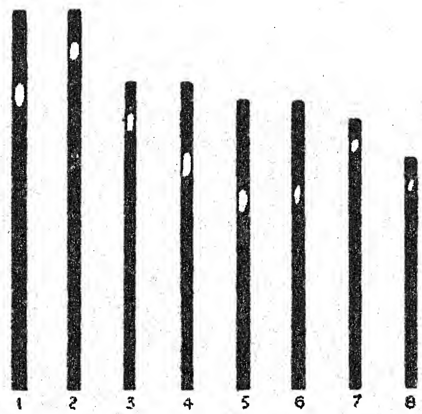

Fig. 2. Late prophase in a tetraploid cell of the onion root tip. 32 chromosomes are found splitting lengthwise. The position of centromeres is quite clear. The size of the cell in this case was just the double of an ordinary diploid cell.

Fig. 3. Representation of the chromosomes illustrating relative lengths and position of centromeres (clear oval shaped). No heterochromatin zones were noticed.

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